Psych
B87332ch

Brooks, Fowler Dell

Changes in mental traits with age, determined by annual re-tests.

-.2
B

Changes in Mental Traits with Age
Determined by Annual Re-Tests

By

FOWLER DELL BROOKS

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, in the Faculty of Philosophy, Columbia University

LIBRARY
JUN 20 1922
UNIVERSITY OF TORONTO

Published by
Teachers College, Columbia University
New York City
1921

LIBRARY
FEB 16 1955
UNIVERSITY OF TORONTO

Changes in Mental Traits with Age

Determined by Annual Re-Tests

By

FOWLER DELL BROOKS

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, in the Faculty of Philosophy, Columbia University

Published by
Teachers College, Columbia University
New York City
1921

Copyright, 1921, by Fowler Dell Brooks

Psych
B87332ch

612933
4.7.55

ACKNOWLEDGMENT

To the late Professor Naomi Norsworthy and to Professor E. L. Thorndike, of Teachers College, I am indebted for suggestions which led to the selection of the problem of this research. Stimulating, helpful supervision of the work of this research is but one of the many things for which I am deeply indebted to Professor Thorndike.

For their coöperation in giving the tests I am under obligation to the critic teachers of the intermediate and junior high school departments of the Training School of the Mankato, Minnesota, State Teachers College.

Very great assistance has been rendered by my wife, Stella Nattier Brooks, in scoring papers, calculating coefficients of correlation and correcting them for attenuation, making long and tedious computations for tables, and checking all calculations.

F. D. Brooks

Digitized by the Internet Archive
in 2008 with funding from
Microsoft Corporation

http://www.archive.org/details/changesinmentalt00broouoft

CONTENTS

INDEX OF FIGURES

TABLES

I

PURPOSE AND PLAN OF THIS INVESTIGATION

In discussing the influence of maturity upon individual differences, Thorndike (1914, pp. 275ff.) points out the complexity of the problem in the respect that changes in an individual's mental traits with age may possibly be due to at least three factors: (1) the maturing of the trait, (2) the influence of training upon it, and (3) "the influence of both maturity and training upon the ability to understand and the wish to follow instructions and the ambition to do well in tests." He further insists that a knowledge of differences in mental traits with age does not tell us much about the influence of maturity upon these changes unless we can parcel out their causes among these three factors, and, that such parcelling out is practically impossible. Turning to the more general problem of changes with age he says, "So far upon the supposition that by changes in mental traits with age, we mean changes in the same individuals measured at different ages. The average change would then be the average of the changes in all the individuals studied. But in the studies that have been reported, the difference between the figures for, say, ten and eleven years, is not the average of the changes of all the individuals studied and need not in any real way describe them.

"For (1) the difference between the average of a group at ten and of the same group at eleven years does not describe the real individual changes; and (2) when we measure ten- and eleven-year-olds as we find them in school or elsewhere, we cannot be sure that the eleven-year-olds represent what the ten-year-olds will become . . . To measure the development of mental traits with age we must repeat measurements upon the same individuals and for all purposes of inference preserve intact each of the individual changes."

This investigation seeks to find out what changes in mental traits take place with age, and it seeks to find them out in the only way they can be found out accurately—by discovering what changes actually do take place in the same individuals from one

year to another. This involves re-testing the same individuals and giving appropriate statistical treatment to the resulting data. Two other purposes are (1) to investigate the correlation between mental functions at different ages of the same individuals, and (2) to study the relation of intellectual ability to rate of improvement over a longer period of time than has heretofore been reported upon—two years in this case.

II

THE SUBJECTS AND THE TESTS

The subjects were one hundred and seventy-one children enrolled in grades four to nine of the Training School of the Mankato, Minnesota, State Teachers College. They ranged in age from nine to fifteen, and represented a random sampling of various social and economic groups. Practically all of them had been tested by educational or psychological tests before taking the tests given in this investigation. Great care was taken that the conditions of testing, the way the tests were given, and the method of scoring should be uniform and according to the directions usually given in connection with each of the tests. There was practically none of the carelessness or lack of honest effort which is sometimes noticeable when a long series of tests are given by persons not connected with the schools in which the tests are given.

The following tests were selected and were given in May, 1918, in May, 1919, and in May, 1920.

1. Number Checking. Woodworth-Wells Number Checking Tests. Four tests were given each year, crossing out 5's, 7's, 4's and 8's. Ninety seconds were allowed for each test. The score is the sum of the correct cancellations in each test. Omissions and wrong cancellations were very rare, and have been neglected in scoring.

2a. Handwriting Quality. Quality of handwriting in ordinary written work. Class-room teachers selected at random two different sets of papers handed in by children in the ordinary school subjects. These sets were written a week to ten days apart. They were scored according to the Ayres scale, Gettysburg edition, the midpoint scores on the scale being given, and were all scored by a thoroughly competent person. The score given is the sum of the scores on the two papers.

2b. Handwriting Quality. Quality of handwriting on two tests in handwriting, given a week to ten days apart. Scored as in *2a*. The score is the sum of the scores on the two tests.

2c. Handwriting Speed. The two tests of *2b* were also scored for

speed. The score is the sum of speeds in two tests, expressed in letters per minute.

2bc. Handwriting Quality and Speed. As a single quantity to represent the handwriting achievement the quality and speed of *2b* and *2c* were combined by using the arbitrarily chosen formula: Score = Quality + ½ speed.

3. Spelling. Sixty words from columns Q, S, and U of the Ayres Spelling Scale were used. The words were dictated in simple sentences, the pupils copying the sentences. The score is the number of words correctly spelled.

4. Visual Vocabulary. Thorndike Reading Scales A2 and B, Visual Vocabulary. Both tests were given as follows: A2*x* and B*x* in 1918 and 1920, and A2*y* and B*y* in 1919. Comparable parts of the tests were counted so that total possible scores each year were the same. The score is the number of words correct on the two tests, the highest possible score being 190.

5a. Courtis Arithmetic, Form B, Attempts. The four fundamental operations were tested. The score is the sum of the number of problems attempted in the four tests.

5b. Courtis Arithmetic, Form B, Rights. The four fundamental operations were tested. The score is number of problems right in the four tests.

5ab. Courtis Arithmetic, Form B, Combined Attempts and Rights. Combined by the formula: Score = Average of attempts and rights.

6. Woody Arithmetic Scales, Series A. The four fundamental operations. The score is the sum of the problems right in the four tests.

7. Stone Reasoning Test. Stone's directions for scoring were followed, additional weight being given for the more difficult problems, and credit being given for all correct reasoning steps regardless of the numerical computations.

8. Composition. The subjects wrote for fifteen minutes on the common subject, "What I Would Like to Do Next Saturday." The papers were scored by five competent judges, on the basis of the Nassau County Supplement to the Thorndike-Hillegas scale. The score is the average of these five scores.

9. Opposites. Woodworth-Wells, first list beginning "long, soft." Responses that were correct for any commonly accepted meanings of

the words were scored one. Time, 120 seconds. The highest possible score is 20. The score is the number right.

10. Directions. Pintner-Toops Directions Test. Given and scored according to directions given in *Journal of Educational Psychology*, March, 1917. A perfect score is 27, being that of superior adults.

11. Immediate Auditory Concrete Memory. Whipple's three-, four-, five-, six-, seven-, and eight-term lists used. The score is sum of words recalled and written down, regardless of order. Perfect score is 33.

12. Immediate Auditory Abstract Memory. Whipple's abstract lists. Score is sum of words recalled regardless of order. Perfect score is 33.

13. Memory for English Equivalents of Italian Words. On each of three consecutive days pupils were given a printed list of twelve Italian words and English equivalents. Three minutes were allowed for study. These slips were then collected, and printed test slips (containing the Italian words in different order from that of the study lists) were distributed. Two minutes were allowed to write the English meanings. The nine lists used for the three yearly testings were arranged to include words that seemed of approximately equal difficulty, though no attempt was made to standardize them scientifically. The writer doubts very much, however, from a study of the results that the three lists of any year were on the whole equal to the three lists given in any other year. The score is the sum of number of correct English words given in three lists. Perfect score is 36.

14. Substitution, Woodworth-Wells. Five Geometric Forms. Time allowed, 90 seconds. Omissions were very rare. Score is number right minus number of wrong substitutions.

15. Letter-Digit Substitution. Three different tests. At the top of page were printed the ten digits. Under each was printed a letter. Below this key were printed in four rows one hundred ten digits in mixed order. Subjects were allowed 120 secs. on each test, to make the substitutions in consecutive order from the first. The same three tests were given each year. Scores were computed on basis of number right minus number of wrong substitutions. Omissions were very rare and were not considered in scoring. Score is sum of scores on three tests. Perfect score is 330.

16. Reasoning. Part of omnibus test devised by Thorndike and McCall. The score is given in terms of penalties. For the parts used a perfect score would be zero, while the poorest possible score would be 36.

17. Trabue Language Completion Scales. Scale C was given in 1918, scale B in 1919, and scale D in 1920. Scored according to Trabue's directions, each sentence scoring 2, 1, or 0. Perfect score is 20.

18. Thorndike Reading, Alpha 2, Paragraph Reading. Papers scored, using Kelley's tables for computing individual scores (*Teachers College Record*, May, 1917).

19. Army Alpha. Given to those tested in 1920. Scored according to directions given in manual.

20. Thorndike Group Intelligence Test, III, Series L. Given to group tested in 1920. Given and scored according to directions furnished by the author.

The following tests were not given in all three years: *10*, *19*, and *20*. Test *10* was given in 1919 and 1920, the other two being given in 1920 only.

Twenty-six of the subjects took the following tests only: Nos. *1*, *2a*, *2b*, *2c*, *4*, *8*, *11*, *12*, *13*, *14*, *15*, *17*, *18*—twice, at year intervals.

Seventy-eight of the subjects took all of the tests two years.

Sixty-seven of the subjects took all of the tests three years.

III

HISTORICAL SURVEY OF EXPERIMENTAL DATA ON AGE AND CHANGES IN MENTAL TRAITS

1. INTRODUCTION

It is not within the scope of this investigation to consider the literature on the relationship between mental and physical development. Those who desire experimental data on this problem will find extensive bibliographies in Whipple (1910, 1914), Burk (1898), Meumann (1907, 1911), and in the *Psychological Review Index.*

Experimental work first concerned itself with testing one or more functions in one or more individuals—usually adults—to illustrate some psychological law or principle. Then the question of the development of different functions led to the examination of children. The earlier studies were often limited to experiments upon a few children of two or three grades or ages; quite often they were qualitative in character and more or less complex. Later there were devised simpler tests, the results of which could be treated quantitatively. Such quantitative results were often reported according to the grade the child had reached in school, the age, if mentioned at all, being the average age of the grade. There are numerous experimental studies which seek to trace the development of mental functions in this way. Greater refinement and precision in the technique of measurement have finally led to carefully devised, standardized, objective tests and exact quantitative treatment of results, and to the reporting of results, not only by grades but also by age and sex.

There is a vast mass of experimental literature on the problem of age and changes in mental traits. Space permits reference only to the most significant parts of it. It seems wise, therefore, to omit reference to practically all investigations which report results in either of the following ways: (1) by grade only, or by average age (except where average age, such as 9 years, 7 months, 15 days, is the average age of persons within a single year span, e. g., from 9.0 years to 9.9 years); (2) by age, but not seperately for

boys and girls. Reporting by grade is of very practical value in administration and has value in psychological study, but for an exact knowledge of individual differences, especially of differences in growth or development, it is too crude a method; we must have age data as well. I have omitted much of the data not giving results separately for boys and girls in order to bring together results of investigations which have been presented in the same way as my own. I have presented results separately for boys and girls in all tests and at all ages. This has been done, not because of any belief in pronounced sex differences in mental traits or in the development of mental traits, but because it seems desirable that data from all investigations should be presented in such a form as will make them available for any future studies of sex differences.

The efficiency of single mental functions, or of narrow groups of functions, in relation to age, while the subject of a great many studies during the past thirty years, has, still, been investigated in nearly all cases by testing a group of children of different ages once or a few times, with usually only a short interval of a few hours or days between the tests, and with no re-tests of the same individuals six months or a year later to determine individual changes. Age status has been determined from these groups, and the differences between different age norms have been taken as the changes due to age. As Thorndike points out, such changes do not represent the changes in the same individuals, and such differences may or may not be the real individual changes with age.

2. NON-RE-TEST EXPERIMENTS

Any study of changes in mental traits with age must refer to the pioneer work of Binet, who after many years of careful experimentation finally published in 1905 the Binet-Simon tests of intelligence, which were revised, by the authors in 1908 and in 1911, by Goddard, by Kuhlmann, and later, by Terman and others at Stanford University. All of this work is too well known to require any further reference or any evaluation.

Binet and Henri (1894) after testing school children on memory of words say, "We have not succeeded in establishing clearly, in the primary elementary schools, which include pupils from seven to

twelve years of age, the influence of age on the number of words reported. We do not doubt that this difference exists but it is possible that it produces an effect little marked between seven and twelve years; it is possible also that the conditions, always changing a little some of the group experiments, have introduced into the results of different classes, some differences which have masked those of age...One observes between the first class (cours supérieur) and the fourth class (cours élémentaire) (the highest and lowest grades of the elementary school) a mean difference of less than one word." Later experiments by other investigators have shown that there is a difference in memory span, between ages seven and twelve, of one to two words.

Another of the earlier important studies of purely mental functions was that of Ebbinghaus (1897), who examined several hundred school children, using mental arithmetic, memory, and his "combination method." His data are given by grade or class, and by sex, though the average age of the classes is also given.

Ziehen (1898) investigated the association of ideas in children eight to fourteen years of age. He is one of the first to use re-tests of the same individuals over a period of a half year or more; some of his subjects were re-tested over a period of two and a quarter years. He concluded that the speed of association (free or uncontrolled) increases with age, whereas Winteler, Wreschner, and Rusk (1909) find that "for different children the speed of association bears no direct relation to age," and that "no conclusion, however, can be drawn from present results as to the relation of speed of association to age in the case of the same child." Ziehen's re-tests are more reliable measures of what age means for an individual, but he took no account of practice effect, nor did he re-test enough individuals to give any conclusive results.

Smedley (1902) investigated the development of immediate memory by testing 937 Chicago boys and girls, ages seven to nineteen, in visual and auditory memory for digits. Finding small sex differences, he reports data for sexes combined. Auditory memory develops more rapidly up to fourteen than thereafter, though there are times of slow growth, notably from eight to nine and from eleven to thirteen; visual memory develops more rapidly also up to fourteen, with gains and losses after that time, reaching, however, as in the case of auditory memory, its highest point at nineteen. Smedley

says of his results, "There is no 'memory period', no period in early school life when the memory is stronger than it is at any later portion of the child's life, a period especially adapted to memorizing." I give here his results in terms of per cent correct at different ages.

Age	*No. Tested*	*Aud. %*	*Vis. %*	*Age*	*No. Tested*	*Aud. %*	*Vis. %*
7	19	36.4	35.2	14	114	66.2	80.5
8	58	44.6	42.8	15	94	65.6	78.2
9	100	45.0	47.4	16	77	66.9	81.3
10	89	49.4	56.4	17	56	65.5	84.1
11	91	55.4	64.7	18	25	67.2	77.5
12	93	55.7	72.3	19	12	70.0	85.3
13	109	57.9	76.8				

We do not know just how typical of school population were the children examined by Smedley; selection no doubt was playing a part during the later ages; nor do we know how well those examined do represent all children of the same ages. Thorndike (1917) has shown that school population is made up of a selected group and that the higher the age, the greater is the amount of selection. In the absence of any careful study of the composition of the group tested we can only guess at the extent to which they represent children of these ages.

Winch (1906), interested in Dr. Rivers' investigations of visual illusions among primitive peoples, conducted an experiment upon 42 English boys, ages eight to fifteen, to see if the civilized child passes through the same stage of development found in the savage. Three different tests of the vertical-horizontal illusion were made with each boy for each of the three forms of the test. Recalculating his data upon the age basis, and computing the illusion in the average per cent of error for each age, we get the following:

Age	8	9	10	11	12	13	14	15
Error in Per Cent	14.09	16.92	9.29	11.31	6.13	5.63	5.41	3.10

The small number of cases, two to eight at each age, enables us to say merely that the amount of illusion seems to decrease with age.

Norsworthy (1906) gives results of different tests given to children of different ages. Some of the tests were given by herself and others by Professor Thorndike. The following tests were given to the number of children (between ages eight and sixteen) indicated after each test: *A* and *a-t* tests, 900 cases; memory for related words, 288 cases; memory for unrelated words, 270 cases; part-whole test, 504 cases; genus-species test, 511 cases; opposites I, 605 cases; opposites II, 608 cases. Dividing the gross gains from one year to the next by the average of the P.E. for ages eleven, twelve, and thirteen in each test, and combining the tests which were given to the same children, we have the following P.E. gains from one year to the next:

Age	*A and a-t*		*Memory Related and Unrelated*		*Part-Whole Genus-Species*	*Opposites I Opposites II*
	B	*G*	*B*	*G*	*B and G*	*B and G*
8–9	.423	.273	.568	.613	.650	.615
9–10	.554	.329	.278	1.072	1.000	.500
10–11	.773	.592	.079	.342	1.550	.748
11–12	.654	.482	.468	−.257	.000	.452
12–13	.452	.420	.212	.146	.200	.352
13–14	.552	.527	.164	.323	.000	.302
14–15	.404	.312	.000	.000	.100	.185
15–16	.403	.242	.107	.261	.000	.152

The results above age thirteen must be considered in the light of the following statement by Norsworthy: "In some of the measurements I could not obtain enough records from school children over thirteen to make the standards of median and probable error reliable. In these cases, as I have records from adults, I followed the general trend of the curve and filled in the standards for ages fourteen, fifteen and sixteen. This is especially true of the intelligence tests." It should be noted that on the whole there is a gain in all functions with age.

It should be noted here that the cancellation of letters, digits, etc., is one of the most widelv used tests. This is now known to be a test

of the lower or simpler functions. Norsworthy classes it as a maturity test. Its correlations with intelligence have been found to be small but positive, Brown (1910), Burt (1911), Simpson (1912), and Wyatt (1913) finding coefficients from .00 to .45; Whipple (1914) found negative correlation with intelligence. Pyle (1915) says of this test, "Ability to do the cancellation test has no relation to the ability shown in the other tests"—completion, logical memory, opposites, genus-species, part-whole, word-building.

Ellison (1903) studied the definitions given to twenty-seven abstract words by 209 boys and 253 girls, ages eight to fifteen. Definitions were classified as those (*a*) by sample, (*b*) by abstract phrases, and (*c*) by equivalents (synonyms and fair definitions). The first kind of definition was very common with eight- and nine-year-olds, but was much less common with increasing age. Definition by abstract phrases increased in frequency up to twelve years "with a slight (though perhaps accidental) fall for the thirteen-, fourteen-, and fifteen-year-olds." Definition by equivalents increased noticeably with age in the case of both boys and girls. The girls were found superior to the boys at almost all points in ability to define. The progressive organization of experience in more complex ways, evidenced by increased ability to define abstract words, is shown to be an accompaniment of increased age.

Tucker (1911), also interested in Rivers' studies, conducted an experiment upon 124 elementary school children in Cambridge, England, and 41 English adults to find the effect of age upon color vision for red, blue, and yellow. The thresholds for boys and girls, ages five, six, seven, eight, and ten, show a decrease as we go from younger to older. The average thresholds are as follows:

Age	*5*	*6*	*7*	*8*	*10*
Boys	72.0	69.0	53.2	46.9	37.0
Girls	83.0	60.4	54.4	45.3	38.0

Chotzen (1912) after testing 236 mental defectives in the Hilfschule at Breslau concludes (as do Bloch and Lippa after their re-tests of mental defectives) that the development of the feeble-minded follows that of the normal, only in retarded rate, and that the greater the age, the greater the retardation. His distribution curves, showing the retardation by ages of the defectives, tested by the Binet-Simon tests, have pronounced modes as follows: for

the seven- and eight-year-olds at one year retardation, for the nine-year-olds at two years retardation, and for the ten-to-thirteen-year-olds at three years.

Smith (1913) with 25 boys and 5 girls of six and twelve years, in perception of facts in pictures, found that perception becomes more complex with increase of age, that there is greater power of analysis, a more active mental attitude, more improvement in discovery of detail, and greater individual differences among the older children.

Valentine (1913) tested 195 Dundee boys and girls, ages six to thirteen, and 146 adults in appreciation of eight concords and four discords played on the piano. Beginning at seven, as age increases there is a steady decline in the score representing the appreciation of the discords, the lowest score being that of the adults. With the concords the results are not so unambiguous, the appreciation score increasing until nine, and decreasing markedly at twelve and thirteen to a point slightly below that of adults. But the octave was one of the concords and probably accounts for part of the lower score at twelve and thirteen.

Von Käthe and Busemann (1914) tested 487 children of the Volksschule in Essen, ages eight to fourteen, in power of observation and attention. They made eight tests, each time using three series of ten nouns each. They found average gross gains in words as follows:

Age	*8 to 9*	*9 to 10*	*10 to 11*	*11 to 12*	*12 to 13*	*13 to 14*
Boys	.8	.8	.8	.5	.4	1.0
Girls	.8	1.1	.6	.8	.1	.6

No variabilities are given. They find thus an increase with age for both sexes, and the smallest gains for both sexes at twelve to thirteen.

Thompson and Smith (1915) sought to determine the recognition vocabulary of children of different ages by using a random sampling of 170 words out of a dictionary containing 35,100 words. They tested 238 boys and 229 girls, ages nine to fourteen. They find an increase in vocabulary with age; there is no increase with boys from thirteen to fourteen, but a rapid increase from eleven to thirteen: girls increase most rapidly from ten to eleven, and from twelve to thirteen. They found the P.E. due to sampling to be .019

or 700 words at ages eleven and twelve. I give here the per cent correct at different ages.

Age	*9*	*10*	*11*	*12*	*13*	*14*
Boys	14.7	15.3	15.6	18.1	20.7	20.6
Girls	14.6	15.2	16.5	17.2	19.0	19.7

Their results correspond rather closely with those of Terman and Childs (1912) who tested orally 161 children, ages five to thirteen, and with those of Whipple (1915) who tested college students and members of the George Junior Republic, ages fourteen to eighteen. Kirkpatrick, on the other hand, found results which would indicate larger vocabularies than those found in the other three investigations. Terman and Childs found small increases from ten to eleven and from six to seven—one hundred words at each of these times.

Anderson (*See* Whipple 1915) carried on extensive experiments upon 405 boys and 421 girls, ages eight to sixteen, in memory for letter-squares, each subject making ten trials. From the data given by Whipple, I have calculated the average score for each age and sex.

Age	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
No. of Boys tested . .	21	43	54	61	72	68	43	31	12
Score . . .	106.43	116.86	118.33	135.33	158.47	153.09	156.63	165.32	172.5
No. of Girls tested . .	31	48	61	65	67	57	53	26	13
Score . . .	106.61	109.17	127.79	143.77	153.36	154.82	165.57	169.23	185.7

It will be seen from these figures that the thirteen- and fourteen-year-old boys did not make as high scores as the twelve-year-old boys, and that ability in this function increases with age, being greatest at the highest age for which data are given. In the case of the girls there is an increase from eight to sixteen, at each age. While I have not computed the variabilities, the gross gains tell us that the point of lowest gain for the girls is probably from twelve to thirteen. The median score, however, of the thirteen-year-old girls is less than that of the twelve-year-olds; also the fifteen-year median is less than that of the fourteen-year-olds. This means negative gains if we use the median as the measure of central ten-

dency, but positive gains if we use the average. Without any discussion of the relative merits of the two measures, such discrepancies between the kinds of gain revealed by different statistical treatment of the data, should make us very cautious in our statements about the rates of gain. When we compare the boys' averages and medians we find by using the median that the same conditions exist as shown by the average with the following exceptions: the ten-year median is a fraction less than the nine-year median, and the sixteen-year is less than that of the fifteen-year-old boys.

Ballard (1913–14) gives performance norms in the fundamental operations in arithmetic for 9176 boys and 9502 girls, ages eight to thirteen and a half, from sixty-nine London elementary schools. There were sixteen addition problems, each of four rows of three-place numbers; twenty-four subtraction problems of four-place numbers; twenty-eight multiplication problems, each of a three-place number by a one-place number; twenty-four short division problems, each of a four-place number by a one-place number. Each column correctly done in addition and subtraction, and each simple process in multiplication and division, each scored one point, so that an example correctly done in addition scored three; in subtraction, four; in multiplication, three; in division, three. Results are given for half-years. No variabilities are given. The time of each test was five minutes. Combining the scores in the four tests by adding the average scores at each age, we have the following performance norms, for boys and girls combined:

8	*8½*	*9*	*9½*	*10*	*10½*	*11*	*11½*	*12*	*12½*	*13*	*13½*
63.	74.5	88.	105.	123.5	140.	133.	165.5	178.	188.5	197.5	205.5

At eleven only, is the score less than that of the previous half-year. If the scores had been combined by years, rather than by half-years the scores at each succeeding year would be greater than the score immediately preceding it. In the tests some children finished before time, and so were not fully tested; beginning at age twelve from 5% to 20% of the group did this; at thirteen and a half from 12% to 40% finished the tests before time was up. The differences between scores at the higher ages would have been greater had longer tests been given. Ballard also found that "the accuracy that comes with age varies directly as the speed of working."

Gray (1915–16) gave Dr. Ballard's tests to 3645 boys and 3715

girls, ages eight to thirteen, in the Leeds elementary schools. Results are given separately for boys and girls. No variabilities are given. Combining the results of the four tests we have the following:

Ages	*8*	*8½*	*9*	*9½*	*10*	*10½*	*11*	*11½*	*12*	*12½*	*13*
Boys tested	289	313	360	346	383	371	403	340	398	354	88
Score	49	74	90	110	126	142	158	167	171	185	192
Girls tested	286	338	345	350	387	355	398	400	404	342	106
Score	47	66	89	103	112	135	142	154	166	174	185

Here, as in Ballard's data, we find from 3% to 14% of the children at twelve and a half finishing before time, and 4% to 23% of the thirteen-year-olds. Errors on the whole were found to diminish as children grow older. The gain by years is shown to be fairly constant. As in Ballard's experiment more problems in each test would undoubtedly have shown greater gains in the higher years.

Green (1915–16), using more carefully devised tests than those used by Ballard (a better selection of problems as to the number combinations involved, and enough problems in each test to avoid any child's finishing before time), tested 800 children, ages eight to thirteen. The averages, medians, and S.D.'s by half-years are given for boys and girls separately, for each of two schools. The gains from year to year in the four tests, in terms of the average S.D.'s of ages eleven, twelve, and thirteen, are as follows:

Age	*8 to 9*	*9 to 10*	*10 to 11*	*11 to 12*	*12 to 13*
Boys	....	.892	.550	.412	−.048
Girls	.648	.686	.388	.088	.465

Ballard (1915–16) tested 22,670 children (11,588 boys, and 11,082 girls) of the London elementary schools, using the Starch one-minute oral reading test. The results are given by half-years from ages six to ten, and from thirteen and a half to fourteen, for boys and girls separately. Ability as measured by this test is shown to increase with age, though the rate of increase is not regular. It is doubtful if much value attaches to a one-minute test of a reading function.

Kimmons (1916) tested 1920 boys and two different groups of girls, totalling 3552, ages seven to thirteen, for speed of handwriting in a five-minute test. His data show the following results in letters per minute:

Age	*7*	*8*	*9*	*10*	*11*	*12*	*13*
Boys	13.9	17.4	25.1	32.9	44.7	46.6	...
Girls (2488) . .	18.8	21.4	29.3	36.1	44.5	49.3	...
Girls (1064) . .	21.6	24.2	34.0	47.6	59.7	64.5	70.5

The first two groups were being introduced to some new method in handwriting, and may not have had time to find their true speed levels. No variabilities are given. The boys' speed is shown by these figures to increase with positive acceleration until the age of eleven, with but slight increase from eleven to twelve. The girls make positive gains at all ages, with positive acceleration probably until the age of eleven, and with decreased positive gains the two following years.

3. RE-TESTS OF THE SAME INDIVIDUALS

There has been reported a small number of investigations in which the same individuals have been re-tested at intervals of a year or half-year, and in which the results have been given by age. Ziehen's re-tests have already been referred to.

Norsworthy (1906) re-tested 26 defective boys and 17 defective girls (ages eight to sixteen) after an interval of one year, using a group of tests. Her conclusions are "(1) That among mental defectives a decided improvement in mental ability may be looked for after a lapse of a year, in some directions even exceeding that shown by ordinary school children. (2) That the greatest improvement is not confined to those defectives most like ordinary individuals. (3) That the improvement is not equal in all directions, but that some mental functions improve more rapidly and to a greater extent than others, and that even the functions we designate as intellectual show marked improvement." She found that the defectives made the least improvement in the intelligence tests; memory tests came next, while the greatest improvement was made in what she calls the "maturity" tests—the *A* and *a-t* tests. Dividing the group into four divisions on the basis of ability shown in the first year's tests, she found the greatest improvement made by the quartiles in the following order: second, third, fourth and first, a condition not in accordance with the generally accepted view at the present time. To the extent that individuals are adequately tested and to the extent that the functions

are not in such a high state of efficiency as to preclude much improvement, to this extent we expect the children of greater ability to make the greater improvement in a given period of time.

Burt (1909–10) re-tested a group of elementary boys of about twelve and thirteen years, eighteen months after the first testing. He does not state just how many were re-tested, but in all probability it was 25, certainly not more than 30. He found that the order of the boys was not materially changed in the second tests. A "dull" boy who stood twenty-fifth in 1908 in the combination of six tests, in 1909 made the same score made by the fourth boy in 1908, yet he still ranked twenty-fourth. Burt says, "The data may be summarized most briefly by expressing the improvement or deterioration for the set of boys re-tested as a percentage of the average calculated for the same set of boys from the original experiments" and gives the following results: "Touch −3%; Comparing Lines 8%; Dealing 15%; Card Sorting 6%; Alphabet Sorting 4%; Memory −9%; Spot Pattern −7%; Dotting −3%; Mirror 31%." The second tests were found to correlate almost as highly with the first as the first ones did among themselves; i. e., $r = .51$ to .76. Burt concludes that the capacities tested "appear to constitute a relatively permanent endowment and consequently it seems legitimate to assume that they depend upon innate differences in the individuals concerned."

Bobertag (1912) examined 83 normal children, using the 1908 Binet-Simon tests, and re-tested the same individuals a year later. He correlated early and late scores using Spearman's rank formula. He found $\rho = .95$, P.E. $= .024$. He calls attention to the tests being too easy at the earlier ages and too difficult at the later ages, the curve being much like the practice curve, rather than a straight line. This is in agreement with the findings of other investigators. Moore tested 252 normal English boys and 239 normal English girls, ages four to thirteen. At four the IQ was 109; at thirteen, 86. Such investigations are interpreted upon the assumption that mental growth continues, and that the tests themselves are not as well selected as they should be.

Bloch and Lippa (1912) tested 71 feeble-minded children at Kattowtz by the 1908 Binet tests, re-testing the same individuals a year later. They conclude that the mental development of the feeble-minded follows closely that of normal children, only remaining

from two to four years behind the normal, and finally remaining at a much lower level.

Dr. F. Kuhlmann, Director of Research at the Minnesota School for Feeble-Minded, has re-tested every two years since 1910 all inmates over three years of mental age and under twenty years of chronological age. His results have not yet been published. In a letter to Dr. Leta S. Hollingworth, quoted by her in *Psychology of Subnormal Children* (1920, p.105), he says, referring to preliminary tabulations made a few years ago, "On the whole the IQ for a given case remains constant, with a slight tendency on the average to decrease after the ages of nine and ten. To this general rule there are quite a number of individual exceptions. A good many cases deteriorate, for whom the IQ will then drop suddenly, and this may be at any age. In a smaller number of cases the IQ increases with age, very markedly in rare instances, more or less frequently in a degree which may be accounted for possibly by an increasing familiarity with the mental tests through repeated examinations. Also there seems to be the tendency for the mental ages to increase very slightly beyond the chronological ages of fifteen or sixteen."

Berry (1913) tested 82 children (42 school children at Ann Arbor, Mich., chronological ages seven to twelve, and 40 mental defectives, chronological ages nine to twenty-four) by the Binet scale, re-testing them one year later. The school children who tested "below age" in 1911, gained .96 years during the following year; those "at age" gained 1.02 years; those "above age" gained 1.17 years; average gain 1 year. The average gain of school children "above age" was 20 per cent more than that of the school children "below age" in 1911.

The defectives (mental ages four to eleven) made an average gain of .5 years during the year. The defectives under fifteen years of chronological age gained 50 per cent more that those over fifteen years of chronological age.

Goddard (1913), using the Binet scale, made three annual testings of 352 feeble-minded at the Vineland Training School. His results are summarized as follows: 109 remained absolutely the same; 232 varied not more than 2 points in the two years; 22 gained more than 5 points (i. e., more than 1 year) in two years—all of these were younger cases; 19 lost 3, 4, or 5 points—all of these were older cases.

Goddard also made three annual testings of 464 public school children, but the results are not reported in such form as to give any information on the problems of this investigation.

All of the results, too, are subject to some error, due to the incorrect mental ages of the Goddard-Binet scale. (See Thorndike 1914–15, p.189.)

Jones (1917) found the correlations of the total test average for each year by the Pearson product-moment formula for 203 Cincinnati children, tested at age fourteen, and re-tested at fifteen, sixteen, and seventeen, in the following tests: cancellation, four pages of digit-symbol substitution, immediate rote memory for digits, a sentence completion test, and opposites. The test average was found by assigning to each individual as his score in each test the number representing the decile division into which his actual score in that test placed him; these decile numbers for all tests were averaged to give his yearly test average. This classifies each child by giving him a rank from 1 to 10 in each test; these ranks are averaged, and the averages are correlated by the Pearson formula. Giving these ranks throws away some of the refinement of the test scores. A better procedure would have been (1) to find for each test each individual's plus or minus deviation from the average of the same age in each test; (2) to express these deviations in each test in terms of the variability, say, the average variability of ages fourteen, fifteen and sixteen, of that test; (3) to average these plus or minus sigma (or Q) deviations of each individual in all tests at each age; (4) to correlate these averages at the different ages. This procedure preserves the refinement of the original test scores, and at the same time makes possible a legitimate combining of results of several tests.

Jones found the following coefficients of correlation:

	Second Year	*Third Year*	*Fourth Year*
First year average .	.74	.69	.76
Second year average	. .	.71	.76
Third year average .	. .	. .	.73

The correlations were found for the individual tests from year to year, as were also the partial correlations with school grade

reached equalized or made constant. Two conclusions are of significance in connection with the problems of this study: (1) "We believe that the varying conditions of work in Cincinnati after the age of sixteen, and perhaps other factors, have operated to make the good slightly better, and the poor relatively poorer than they were at the age of fourteen" (p.84).

(2) One well-rounded testing of an individual probably gives his general intellectual rank for several years.

Woodrow (1917) carried out a practice experiment which is important in its relationship to a re-test experiment by Murdoch (1918). Woodrow devised and carried out in a thoroughly scientific manner an investigation upon 40 normal and 32 subnormal children of the same mental age (nine), to determine whether or not feeble-minded children show the same improvement with practice as do normal children of the same mental age. The experiment involved sorting gun-wads upon which had been pasted the five geometrical forms of the Woodworth-Wells substitution test, and extended over a period of thirteen days. Both practice and control groups of normal and subnormal children were used. In both the amount of improvement by practice, and the amount of transfer or spread of practice, Woodrow found the feeble-minded showing the same improvement as the normal children of the same mental age. In contrast with this is the experiment of Murdoch, referred to above. Thirty-seven feeble-minded children of known mental age were tested by measuring their achievement in reading, arithmetic, spelling, handwriting, composition, language, and drawing; a year later 21 of them were re-tested and their rate of progress compared with that known to obtain in the case of normal children. The rate was found to be much less. The results led to the conclusion that what Woodrow found in the case of the simpler functions over a few days' practice was not true in the case of the higher or more complex functions over a longer period of time. It remained for Hollingworth to point out that there is no discrepancy or antagonism between the results of the two experiments, because in the latter one, at the end of the year the subnormal children are no longer of a mental age equal to that of the normal children with whom they were compared. This is but another way of saying that the rate of mental growth is slower in the case of the subnormals than in that of normal children.

Terman (1919) reports the results of re-tests of 315 children, ages three to fifteen at the time of the first test. The Stanford-Binet test was used. Some children were tested twice, others several times. The intervals between the tests varied from one day to seven years. Omitting tests which were less than a year apart, there are 349 comparisons of tests with re-tests at intervals of one to seven years. Terman summarizes the findings by noting (1) that the central tendency of change is an increase of 1.7 points in IQ; (2) that the middle 50 per cent of change lies between an increase of 5.7 points and a decrease of 3.3 points; (3) that the P.E. is 4.5 points; (4) that the correlation between earlier and later tests is .933; (5) that tests more than five years apart show a greater tendency toward an increase in IQ than is found in the case of tests at shorter intervals (though this may be due to some differences between the form of the test used in the earlier and that used in the later trials). Mental growth curves are given for several children. The slopes of the curves indicate that the higher the degree of intelligence the greater the mental growth per year.

Baldwin and Stecher (1921) report the results of four annual testings of normal and superior children in the Observation School at the University of Iowa, by the Stanford Binet scale. The number of children tested is not given. The conclusions are as follows:

1. Considerable fluctuations of individual IQ's in successive years.

2. The average children remain average, and the superior children remain superior.

3. Superior children are more variable than average children.

4. Older children (chronologically) are more variable than younger children.

5. A general tendency for IQ to increase at later examinations, especially in the case of older children and children of superior ability.

6. The correlations at intervals of one, two, and three years by the Pearson formula are as follows:

$$r12 = +.85$$
$$r13 = +.748$$
$$r14 = +.780$$

The method of computing the correlations is not given, so we do not know if the age factor has been eliminated or made constant

(by taking mental-age deviations from normal). If this has been done, these coefficients signify that the differentiation of children by levels of intelligence is relatively permanent, and are direct evidence that the average remain average and that the superior remain superior.

Doll (1921)[1] reports the results of re-tests by the Goddard-Binet scale of 203 mental defectives at the Vineland (N.J.) Training School, covering at least a five-year period for each individual. He also gives re-test data from a group of superior children attending the Ethical Culture School in New York City.

4. DATA RECALCULATED FOR DIRECT COMPARISON WITH RESULTS OF MINNESOTA RE-TESTS

The results of the following investigations I have recalculated and turned into suitable form for comparison with my own data:

Dr. Gilbert (1894) at Yale University made one of the most careful and extensive early studies of differences in mental traits between children of different ages, from six to seventeen. Approximately fifty school children of each age and sex were tested in the following mental traits: (1) Delicacy of discrimination of weight—"muscle-sense"; (2) delicacy of discrimination of colors; (3) force of suggestion—size-weight illusion; (4) voluntary motor ability—tapping; (5) fatigue in tapping; (6) reaction time; (7) reaction with discrimination and choice; (8) time—memory. Ten trials were made by each individual in each test. The median for each age and sex in each test, and the average deviation (mean variation) for each age and sex in each of the last five tests, are given; in the first three tests the average deviation is given for boys and girls together only.

Netschajeff (1900) tested 687 St. Petersburg school children, ages nine to eighteen, in eight memory tests—objects, sounds, numbers, and words referring to sound, sight, touch, feeling, and abstract relations—of twelve each. He gives the average performance in each test for each age and sex. No variability is given.

Lobsien (1901) tested 462 Kiel children, ages nine to fourteen and a half, in eight memory tests, seeking to be more accurate than Netschajeff.

[1] This monograph came to hand too late for a summary of it to be included in this report.

Pyle (1913) gives age-norms (average and average deviation) for each sex and age from eight to eighteen in the following tests: (1) Logical memory; (2) immediate concrete memory; (3) immediate abstract memory—Whipple's lists in this test and in number two; (4) digit-symbol; (5) symbol-digit; (6) word building—aeirlp; (7) word building—aeobmt; (8) uncontrolled association; (9) opposites; (10) genus-species; (11) part-whole; (12) cancelling *A*'s. His tests, with few exceptions at seventeen and eighteen and one at fifteen, were given to from forty to eighty subjects of each age and sex. All tests were given at the different age-levels to the same group of subjects, so that the twelve test-norms for thirteen-year-old boys mean that a particular group of thirteen-year-old boys took all twelve of the tests and made the average scores given for each test.

Pyle (1920) extended his investigations to a great many more subjects; in the case of city children he tested from one hundred thirty to four hundred fifty of each age and sex, from eight to sixteen, and from fourteen to ninety-eight of each age and sex at ages seventeen and eighteen; in the case of the country children he tested twenty-one to one hundred ninety-nine of each age and sex from eight to eighteen. Very nearly the same tests were used as in 1913. The average for each age and sex is given for each test, but no variabilities are given.

Bickersteth (1914–15), of Oxford University, carried out a carefully devised and very carefully administered series of tests upon six different groups of school children. The ones that are of special interest and value in connection with my own data are the twelve tests given to 550 girls in Oxford higher elementary schools, ages five to sixteen, and five tests (Nos. *3*, *4*, *5*, *6*, and *12*) given to 600 boys and girls, ages nine to thirteen, in the Yorkshire Dales elementary (rural) schools. The first group numbers from eighteen to seventy at each age; the second group numbers eighteen to seventy-four for each age and sex. Each test was given twice, the testings for each child in each test being one week apart. Bickersteth groups the tests as follows: I. *Motor Tests:* (1) Power of sustained effort—tapping; (2) fatigue in tapping. II. *Tests of Discriminative Selection:* (3) Alphabet cancellation; (4) number cancellation; (5) combined number and alphabet cancellation. III. *Memory Tests:* (6) Memory for narrative—logical memory; (7) memory for related words; (8) memory for unrelated words. IV. *Tests of Analytic and Synthetic Apper-*

ception: (9) Spot-pattern test. V. *Tests of Attention:* (10) Sustained voluntary attention—dotting; (11*a*) Discs—concentrated attention; (11*b*) Discs and sentences—divided attention. VI. *Reasoning:* (12) Analogies.

Woolley and Fisher (1914) in Cincinnati have carried on a very significant investigation at the Vocation Bureau. They have tested those who apply for work permits, and have re-tested many who come back for new permits, and they have sought out and re-tested as many others as they could. Such re-tests have been very nearly a year after the previous tests. Data are published for seven hundred fifty who were tested at fourteen and again at fifteen. The data are given in terms of the median and Q for each age and sex in each test. For purposes of telling about changes in individuals the central tendency and variability of the differences between each individual's score at fourteen and his score at fifteen would be preferable, but the central tendencies of the same group at fourteen and again at fifteen are much better than the same data for different groups at the different ages. The following tests have been given: (1) Tapping; (2) fatigue in tapping; (3) card-sorting; (4) cancellation of A's; (5) memory for digits, seven-, eight-, and nine-place; (6) memory span; (7 *a*, *b*, *c*) substitution, digit-geometrical forms; (8) substitution, memory digit-geometrical forms; (9) sentence completion; (10) opposites.

Under Dr. Woolley's direction this investigation has been continued now for more than five years. Not only have the tests been very carefully given and the results carefully tabulated, but there has been also a large enough number of individuals re-tested to make it the most extensive experimental investigation by annual re-tests of normal children, ages fourteen to eighteen, that we have up to the present time. Below are given the numbers of each age and sex for both the school group and the working group. (This is the group reported upon in the 1914 publication for ages fourteen and fifteen, while the school group is a control group which has been used as a check against the mental development which takes place with those who go into industry.)

The data are for re-tests of the same individuals in all cases with the following exceptions: nearly one-half of the school group of the ages, fourteen, fifteen and sixteen, had left school by seventeen and eighteen and were replaced by a new group, judged to be practically

Ages	*14*	*15*	*16*	*17*	*18*
Boys:					
School	430	294	289	178	66
Working	420	388	346	309	304
Total	*850*	*682*	*635*	*487*	*370*
Girls:					
School	330	255	240	165	79
Working	327	285	296	244	204
Total	*657*	*540*	*536*	*409*	*283*
Total Boys and Girls	*1,507*	*1,222*	*1,171*	*896*	*653*

the same as the original group whom they replaced. The original data from which I have calculated the gains from ages fifteen to eighteen are soon to be published by Dr. Woolley.

Dewey, Child, and Ruml (1920) have carried out one of the most scientific experimental studies in educational psychology. Individual tests have been given to fifty boys and fifty girls of each age from nine to thirteen in the New York public schools. The children are all Jewish. A random sampling of the three thousand normal children attending the schools from which the children tested were selected, was obtained in the following manner: The age-grade distribution for the whole school in per cents was found. The fifty children of each age and sex were then selected from the different grades of the schools so that for any age or sex the grade distribution was of the same proportion as for all the children of that age and sex in the whole school. Children in special classes were not selected. A wide range of tests was given. Space does not permit any description of them. Those interested in the scientific testing of school children should refer to the book by these authors. The results of the following tests are compared with my own data: (1) Cart construction; (3) narrative pictures; (4) identification of forms; (5) instruction box; (6) needle-threading; (7) nail-driving; (8) picture-completion; (9) problem box; (11) memory for objects; (12) Knox cubes; (13) Healy puzzle A; (15) Healy puzzle B; (16) card sorting; (17) cancellation of *A*'s; (18–19) substitution; digit-geometrical forms; (21) memory span—digits; (23) steadiness of motor control—right hand. The average

of each age-group is given for each test, as are also given the standard deviations, and the P.E.*t.-obt.av.*, and P.E.*t-obt.S.D.* The regression equations are also given for each test. The results of the different tests have been analyzed by means of the partial correlation method to find those tests which do not correlate highly with each other. Such tests have been used to form a maturity scale, due weights being assigned (by the regression coefficients) to the different tests included in it.

IV

STATUS OF THE SUBJECTS BY AGE AND SEX

In considering the status of the subjects tested it is desirable to note their distribution by grade at each age for each sex. Such distribution will throw some light upon the interpretation of the results obtained from the tests. Figs. 1-a to 7-b present graphically these distributions. The fourth grade was chosen as the lowest grade in which to give the entire series of tests, while the ninth grade was the highest grade attended by pupils of the Training School. For various reasons it was impossible to test any pupils after finishing the third year of the junior high school at the Training School. Keeping these facts in mind, an examination of Figs. 1-a to 7-b will show clearly that the groups tested at the earliest and latest ages vary from a true random sampling of normal school population in the following significant respects: (1) By beginning the testing with the fourth grade, the nine-and-ten-year-olds of less ability (as measured by grade reached in school) have been lopped off. To have a true random sampling of school population we should have some children of nine and ten years of the third grade, and some second-grade children nine years of age. This is of still greater significance when we recall that the tests were given during the last month of the school year in a school which makes annual promotions, does not have A and B divisions of grades, but which divides the pupils into two sections according to ability instead, so that grade four really means fourth A, or advanced fourth. It is readily apparent that children who finish the fourth grade before their tenth birthday in a school in which practically all are six years old before entering the first grade, are on the whole superior nine-year-olds. Those finishing the fifth grade are, of course, still more so. Figs. 1-a and 1-b show by their skewness this variation from random sampling. (2) At the older ages there is a cutting off of some children of superior ability. Many children who are just short of their sixteenth birthday have completed the ninth grade. The same is true of a much smaller number who are not yet fifteen. These two facts must be considered when we discuss the rate of improvement from year to year. There are other significant facts

Fig. 1-a—Boys 9 yrs. old

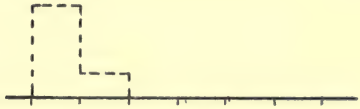

Fig. 1-b—Girls 9 yrs. old

Fig. 2-a—Boys 10 yrs. old

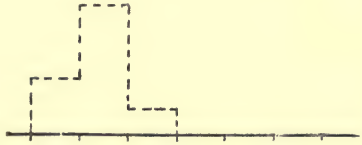

Fig. 2-b—Girls 10 yrs. old

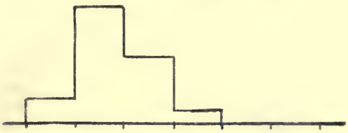

Fig. 3-a—Boys 11 yrs. old

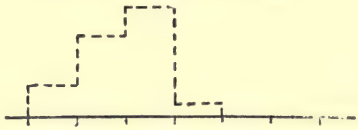

Fig. 3-b—Girls 11 yrs. old

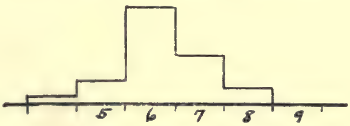

Fig. 4-a—Boys 12 yrs. old

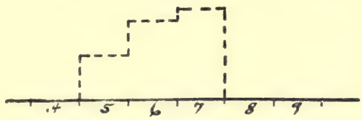

Fig. 4-b—Girls 12 yrs. old

Fig. 5-a—Boys 13 yrs. old

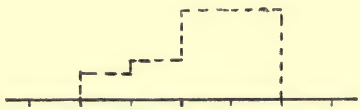

Fig. 5-b—Girls 13 yrs. old

Fig. 6-a—Boys 14 yrs. old

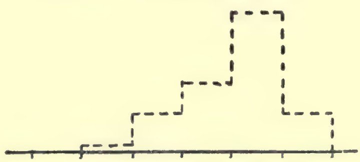

Fig. 6-b—Girls 14 yrs. old

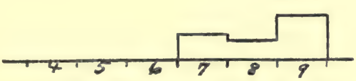

Fig. 7-a—Boys 15 yrs. old

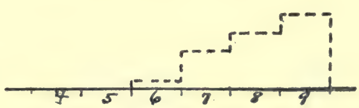

Fig. 7-b—Girls 15 yrs. old

FIGS. 1-A TO 7-B GRADE DISTRIBUTION OF SUBJECTS BY AGE, AND SEX

Note. Age means age on last birthday.

disclosed by these graphs to which attention will be directed in the later discussion.

The results of the tests have been compiled so as to show the status by age and sex in each test. The average, the standard deviation and the P.E.*t.av. – obt. av.* and the P.E.*t.S.D. – obt. S.D.* have been computed for boys and for girls of each age in each test. These data are presented in Table I. The significance of the plus and minus quantities given after the averages and standard deviations will be made clear by the following explanation: The pupils tested represent very small samples of the larger groups—children nine years old, children ten years old, etc. The average achievement (or S.D.) of these small groups probably varies from the average (or S.D.) we would obtain if we tested the larger groups of which they are samples. The plus and minus quantities are the median deviations (called P.E.*t.-obt.*) of the true averages or standard deviations from the averages or standard deviations which have been found for the different groups actually tested, and tell us the chances are even that the true measure will differ from the obtained measure by an amount greater than the plus and minus quantity given after each measure; e. g., to the extent that the nine-year-old boys tested represent a random sampling of nine-year-old school boys, we know the obtained measure is the most probable one, and that in the number-checking test, for example, the chances are even that the true average will not be greater than 115.71 and less than 102.71 (109.21 ± 6.50). To the extent that the sampling is characterized by a distribution which is skew in one direction or another, we must expect the true average to be greater or less than that obtained. Errors of simple sampling, as well as the form of distribution of the groups tested, must be taken into account in interpreting the data on yearly improvement.

TABLE I

SHOWING THE AVERAGE, STANDARD DEVIATION, P.E.*t.av.-obt.av.* AND P.E.*t.-obt.* S.D. FOR EACH SEX AT EACH AGE IN EACH TEST

	Boys				*Girls*			
Age	*Average*		*S.D.*		*Average*		*S.D.*	
	1. Number Checking							
9	109.21	± 6.50	25.50	± 4.60	116.08	± 2.19	14.15	± 1.55
10	101.75	2.67	19.41	1.89	117.97	2.51	21.68	1.77
11	113.33	2.24	19.9	1.58	131.82	2.49	22.8	1.76
12	123.03	2.50	21.0	1.77	145.13	3.52	30.9	2.49
13	139.21	3.41	24.8	2.41	160.16	2.68	24.5	1.89
14	156.12	3.32	24.12	2.35	165.73	2.66	26.16	1.88
15	165.23	6.01	35.03	4.31	169.21	3.21	25.19	2.27
	2a. Handwriting Quality (Ordinary Written Work)							
9	65.00	± 3.41	13.36	± 2.41	74.21	± 1.87	12.06	± 1.32
10	72.92	1.83	13.30	1.29	88.97	2.00	17.31	1.42
11	79.58	1.37	12.2	.97	93.68	2.58	23.6	1.83
12	86.41	1.92	16.1	1.36	109.00	2.85	25.04	2.02
13	95.83	2.37	17.2	1.67	126.84	2.72	24.9	1.93
14	102.92	2.20	16.00	1.56	125.79	2.62	25.78	1.85
15	127.67	2.60	14.92	1.84	138.39	2.77	21.76	1.96
	2b. Handwriting Quality (Writing Test)							
9	70.71	± 2.93	11.47	± 2.07	74.74	± 1.95	12.62	± 1.38
10	74.17	1.76	12.80	1.25	91.32	2.22	19.22	1.57
11	83.45	1.60	14.19	1.13	101.45	2.38	21.76	1.68
12	92.50	2.02	16.91	1.43	112.30	2.74	24.06	1.94
13	101.25	2.75	19.96	1.94	128.95	2.49	22.76	1.76
14	108.96	2.70	19.64	1.91	138.75	2.53	24.89	1.79
15	117.33	3.22	19.52	2.28	146.96	2.40	18.82	1.70
	2c. Handwriting Speed (Writing Test)							
9	124.79	± 7.17	28.13	± 5.07	131.28	± 5.80	37.51	± 4.10
10	125.12	3.34	24.27	2.36	136.56	2.58	22.33	1.83
11	136.73	3.29	29.25	2.33	145.55	2.40	21.91	1.70
12	150.87	3.51	29.45	2.48	156.58	3.19	27.99	2.26
13	159.71	3.78	27.45	2.67	158.82	3.24	29.64	2.29
14	164.17	4.21	30.55	2.97	170.23	2.39	23.50	1.69
15	172.30	3.90	22.40	2.76	179.54	2.20	17.27	1.56

TABLE I—*Continued*

				2bc. Handwriting—Speed and Quality (Writing Test)				
9	128.57	± 4.96	19.45	± 3.51	140.13	± 3.55	22.93	± 2.51
10	137.02	2.56	18.57	1.81	157.99	2.73	23.61	1.93
11	149.89	2.30	20.5	1.63	174.37	3.02	27.6	2.14
12	167.16	3.15	26.4	2.22	190.23	3.04	26.7	2.15
13	181.08	3.41	24.8	2.41	209.18	3.25	29.7	2.30
14	190.75	3.38	24.50	2.38	224.26	2.86	28.09	2.02
15	203.48	4.59	26.37	3.25	236.91	2.94	23.08	2.08
				3. Spelling				
9	25.21	± 2.88	11.28	± 2.03	32.13	± 1.39	8.99	± .98
10	25.93	1.69	12.31	1.20	32.45	1.22	10.57	.86
11	28.81	1.68	14.96	1.19	38.74	1.38	12.57	.97
12	35.34	1.89	15.57	1.33	41.41	1.62	14.2	1.14
13	40.40	1.70	11.26	1.20	46.47	1.58	13.69	1.12
14	42.50	1.93	11.46	1.37	47.60	1.61	13.09	1.14
15	44.83	3.13	13.93	2.22	49.81	2.03	12.06	1.44
				4. Visual Vocabulary				
9	89.07	± 7.15	28.06	± 5.06	102.76	± 4.27	27.59	± 3.02
10	85.33	5.41	39.27	3.82	104.50	4.30	37.13	3.04
11	103.42	4.17	37.1	2.95	115.32	4.30	39.3	3.04
12	126.16	4.72	39.6	3.34	126.13	4.05	35.5	2.86
13	135.71	5.44	39.5	3.85	135.79	3.93	35.9	2.78
14	138.87	5.87	42.61	4.15	143.82	3.28	32.30	2.32
15	143.44	6.82	39.16	4.82	154.93	3.58	28.08	2.53
				5a. Courtis Arithmetic—Attempts				
9	17.07	± 1.16	4.56	± .82	19.82	± 1.09	7.07	± .77
10	21.46	.82	5.95	.58	23.65	.72	6.23	.51
11	23.64	.60	5.34	.42	27.71	.87	7.92	.61
12	27.24	.81	6.72	.58	33.16	.89	7.83	.63
13	31.05	1.28	8.51	.91	37.18	1.11	9.63	.79
14	34.92	1.29	7.66	.91	37.93	1.21	9.79	.85
15	38.72	2.51	11.17	1.78	39.56	1.67	9.93	1.18
				5b. Courtis Arithmetic—Rights				
9	9.79	± .78	3.06	± .55	9.18	± .96	6.22	± .68
10	9.50	.81	5.91	.58	13.91	.81	7.02	.57
11	14.67	.73	6.41	.51	18.61	.93	8.49	.66
12	17.79	.62	5.15	.44	23.73	.98	8.61	.69
13	23.15	1.24	8.24	.88	26.21	1.17	10.09	.83
14	23.00	1.48	8.77	1.05	28.17	1.24	10.09	.88
15	26.50	1.93	8.60	1.37	27.18	1.61	9.53	1.14

TABLE I—*Continued*

				5ab. Courtis Arithmetic—Combined Atts. Rts.				
9	13.78	± .95	3.72	± .67	14.25	± .94	6.08	± .66
10	15.65	.72	5.21	.51	18.53	.72	6.19	.51
11	18.72	.65	5.8	.46	23.21	.83	7.6	.59
12	22.26	.68	5.6	.48	28.22	.92	8.05	.65
13	26.92	1.19	7.9	.84	31.47	1.09	9.4	.77
14	28.97	1.36	8.08	.96	33.65	1.18	9.55	.83
15	30.97	2.23	9.93	1.58	33.37	1.57	9.33	1.11
				6. Woody Arithmetic				
9	74.21	± 2.22	8.72	± 1.57	75.03	± 2.77	17.92	± 1.96
10	79.75	2.70	19.61	1.91	90.21	2.20	19.05	1.56
11	94.89	2.12	18.90	1.50	100.95	2.08	19.01	1.47
12	109.27	1.89	15.6	1.34	111.27	2.06	18.1	1.46
13	115.4	2.49	16.5	1.76	114.09	1.98	17.1	1.40
14	116.94	2.47	14.66	1.75	116.27	1.92	15.60	1.36
15	121.39	2.62	11.66	1.85	117.56	2.57	15.26	1.82
				7. Stone Reasoning				
9	2.75	± .28	1.10	± .20	3.45	± .41	2.66	± .29
10	3.43	.34	2.43	.24	3.83	.23	1.98	.16
11	4.93	.34	3.03	.24	4.77	.21	1.95	.15
12	6.77	.38	3.1	.27	6.39	.30	2.6	.21
13	8.13	.48	3.2	.34	7.09	.37	3.2	.26
14	8.42	.59	3.51	.42	7.65	.38	3.06	.27
15	9.74	.86	3.85	.61	7.83	.46	2.72	.32
				8. Composition				
9	3.00	± .16	.64	± .12	3.39	± .13	.84	± .09
10	2.97	.13	.97	.09	3.99	.10	.85	.07
11	3.21	.11	.98	.08	3.97	.10	.93	.07
12	3.98	.12	.99	.08	4.24	.14	1.20	.10
13	3.46	.14	1.02	.10	4.75	.12	1.06	.08
14	4.49	.14	1.05	.10	5.28	.11	1.12	.08
15	5.05	.16	.90	.11	5.55	.15	1.14	.10
				9. Opposites				
9	8.36	± .40	1.55	± .28	10.71	± .33	2.17	± .24
10	9.75	.39	2.82	.27	11.53	.33	2.82	.23
11	11.03	.38	3.4	.27	11.63	.35	3.2	.25
12	12.98	.53	4.36	.37	11.68	.43	3.77	.30
13	13.60	.58	3.82	.41	11.76	.42	3.65	.30
14	12.87	.79	4.70	.56	12.89	.49	3.97	.36
15	13.39	.93	4.12	.66	13.00	.56	3.34	.40

TABLE I—*Continued*

				10. Directions				
9	12.10	± .56	1.85	± .40	14.04	± .62	3.06	± .44
10	12.27	.87	4.63	.61	16.11	.43	3.08	.31
11	13.46	.43	3.14	.31	16.53	.45	3.62	.32
12	16.06	.41	3.01	.29	16.37	.33	2.82	.23
13	17.70	.57	3.29	.41	17.70	.51	3.81	.36
14	20.70	1.13	5.31	.80	18.34	.57	4.20	.40
15	17.96	1.20	5.33	.85	19.43	.75	4.33	.53
				11. Concrete Memory				
9	20.79	± 1.14	4.46	± .80	20.24	± .61	3.96	± .43
10	20.88	.49	3.59	.35	22.26	.37	3.24	.26
11	22.33	.39	3.5	.28	23.63	.35	3.2	.25
12	24.53	.32	2.69	.23	24.70	.32	2.77	.22
13	25.67	.36	2.6	.25	25.84	.29	2.64	.20
14	25.13	.57	4.16	.40	26.64	.29	2.84	.20
15	26.30	.56	3.32	.40	26.57	.27	2.10	.19
				12. Abstract Memory				
9	14.64	± 1.75	6.85	± 1.24	15.45	± .85	5.51	± .60
10	17.83	.67	4.85	.47	18.35	.46	3.93	.32
11	19.17	.52	4.6	.37	20.16	.43	3.90	.30
12	20.28	.44	3.72	.31	21.64	.38	3.33	.27
13	22.62	.52	3.8	.37	22.53	.33	3.02	.23
14	22.46	.60	4.33	.42	23.11	.37	3.61	.26
15	23.50	.72	4.13	.51	24.18	.41	3.21	.29
				13. Italian Vocabulary				
9	18.07	± 1.32	5.18	± .93	16.24	± 1.84	11.92	± 1.30
10	14.50	1.01	7.37	.72	16.35	.81	7.04	.58
11	16.08	.81	7.2	.57	18.26	.91	8.33	.64
12	18.44	.94	7.92	.67	19.76	1.02	8.95	.72
13	20.75	1.27	9.19	.89	23.24	.94	8.57	.86
14	20.54	1.21	8.76	.85	24.77	.76	7.43	.53
15	20.23	1.43	8.20	1.01	23.79	1.11	8.71	.78
				14. Woodworth-Wells Substitution				
9	38.21	± 2.05	8.06	± 1.45	47.71	± 1.67	10.81	± 1.18
10	40.25	1.37	9.95	.97	48.35	1.22	10.53	.86
11	44.78	1.27	11.3	.90	50.39	1.14	10.4	.80
12	48.96	1.06	8.92	.75	55.41	1.52	13.3	1.07
13	55.54	1.32	9.62	.94	60.37	1.60	14.6	1.13
14	57.00	1.88	13.66	1.33	63.45	1.52	14.90	1.07
15	61.63	2.24	12.86	1.58	62.93	1.70	13.33	1.20

TABLE I—*Continued*

		15. Letter-Digit Substitution		
9	99.93 ± 6.60	25.91 ± 4.67	128.08 ± 3.42	22.08 ± 2.42
10	105.96 3.88	28.18 2.74	138.44 3.33	28.75 2.35
11	117.28 2.91	25.9 2.06	154.47 2.33	21.3 1.65
12	135.84 2.29	19.2 1.62	168.33 3.61	31.7 2.56
13	147.46 3.35	24.3 2.37	181.47 3.92	35.8 2.77
14	160.96 5.21	37.81 3.68	188.95 4.07	40.07 2.88
15	170.17 6.00	34.46 4.24	192.50 4.16	32.61 2.94
		16. Part of Omnibus		
9	18.07 ± .80	3.16 ± .57	15.92 ± .83	5.38 ± .59
10	13.67 .86	6.28 .61	13.68 .80	6.88 .56
11	11.81 .72	6.4 .51	12.76 .72	6.58 .51
12	9.08 .83	6.87 .59	11.47 .70	6.11 .49
13	8.15 .86	5.69 .61	10.00 .62	5.39 .44
14	8.87 1.04	6.16 .73	10.77 .79	6.43 .56
15	9.72 1.49	6.65 1.06	10.00 .94	5.60 .67
		17. Trabue Language Completion		
9	11.07 ± .54	2.13 ± .38	11.50 ± .37	2.36 ± .26
10	11.42 .37	2.72 .26	12.71 .27	2.36 .19
11	11.64 .30	2.7 .21	13.03 .23	2.07 .16
12	12.81 .26	2.17 .18	13.33 .24	2.14 .17
13	13.96 .37	2.68 .26	13.79 .30	2.72 .21
14	13.79 .42	3.08 .30	14.48 .22	2.12 .15
15	14.36 .48	2.63 .32	15.07 .32	2.48 .22
		18. Thorndike Reading—Alpha 2		
9	5.55 ± .09	.37 ± .07	5.94 ± .12	.77 ± .08
10	5.58 .12	.84 .08	6.16 .09	.82 .07
11	6.11 .09	.82 .07	6.40 .07	.63 .05
12	6.65 .09	.77 .06	6.72 .09	.69 .06
13	7.08 .10	.73 .07	7.07 .07	.64 .05
14	7.13 .09	.57 .06	7.33 .07	.71 .05
15	7.19 .12	.71 .09	7.53 .08	.65 .06

In Table II is given the number of boys and girls of each age, taking the tests.

Table III presents data showing the per cent of the boys at each age equalling or exceeding the median girl's score for the same age in each test.

TABLE II

Showing the Number of Boys and Girls of Each Age Taking the Tests

Ages	Tests 1, 2a, 2b, 2c, 4, 8, 11, 12, 13, 14, 15, 17, 18		Tests 3, 5a, 5b, 6, 7, 9, 16		Test 10	
	Boys	Girls	Boys	Girls	Boys	Girls
9	7	19	7	19	5	11
10	24	34	24	34	13	23
11	36	38	36	38	24	29
12	32	35	31	35	25	24
13	24	38	20	34	15	25
14	24	44	16	30	10	25
15	15	28	9	16	9	15

TABLE III

Per Cent of Boys at Each Age Equalling or Exceeding the Median of the Girls of the Same Age in Each Test

Test	Ages						
	9	10	11	12	13	14	15
1 . . .	57.1	20.8	19.4	14.1	16.6	41.7	40.0
2a . .	28.6	10.0	13.9	11.3	8.3	8.3	6.6
2b . .	42.9	10.8	8.3	12.5	9.2	6.6	0
2c . .	28.6	20.8	30.5	45.3	45.8	29.2	26.6
3 . . .	28.6	27.1	27.7	25.1	25.	21.9	33.3
4 . . .	14.3	41.7	33.3	59.4	58.3	54.2	53.3
5a . .	35.7	36.1	34.7	22.6	35.0	34.3	33.3
5b . .	71.4	33.3	30.5	22.9	45.0	28.1	44.4
6 . . .	77.1	29.2	41.6	45.9	50.0	50.0	66.6
7 . . .	48.6	37.5	36.1	54.9	60.0	56.2	55.5
8 . . .	45.7	20.0	16.9	26.8	29.2	24.2	34.6
9 . . .	7.1	20.8	52.7	57.1	66.0	75.0	66.6
10 . .	30.0	15.4	22.9	41.6	33.3	79.0	41.7
11 . .	57.1	39.2	33.3	43.8	50.0	52.1	53.3
12 . .	57.1	53.1	43.1	52.5	53.3	54.2	46.6
13 . .	85.7	50.0	37.5	35.6	47.9	33.3	31.3
14 . .	25.0	29.2	33.3	21.1	25.0	33.3	40.0
15 . .	28.6	12.5	5.5	3.1	16.6	25.0	40.0
16 . .	71.4	58.3	38.8	33.5	35.0	25.0	33.3
17 . .	40.0	37.5	28.3	44.3	54.2	52.1	50.6
18 . .	14.3	38.3	30.6	28.1	37.5	46.6	36.0

V

AMOUNT AND RATE OF YEARLY IMPROVEMENT

I. METHOD OF TREATING DATA

Each child's score in each test was subtracted from his score in the same test the following year. This difference represents his improvement in one year, and is positive or negative. For those tested three years the same procedure was followed, taking the difference between the first and second, and the second and third, tests. These improvements in each test have been grouped according to the ages of the children. May 15 was the median date of testing each year, and so ages have been computed as of that date. The age given on all tables is, in each case, the child's age on his last birthday; thus a child nine years, seven months and twenty-nine days old on May 15 is recorded as nine years of age.

The median yearly improvement in gross score in each test, for each age and for each sex, has been computed and is given in Table V. Table IV gives the number of boys and girls making the improvements shown in Table V.

TABLE IV

Showing the Number of Boys and Girls of Each Age Making the Improvement Shown in Tables V, VI, and VII

Ages	*Tests 1, 2a, 2b, 2c, 4, 8, 11, 12, 13, 14, 15, 17, 18*		*Tests 3, 5a, 5b, 6, 7, 9, 16*		*Test 10*	
	Boys	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*
9 to 10	7	17	7	17	3	9
10 to 11	20	24	20	24	9	13
11 to 12	24	21	24	21	11	12
12 to 13	16	20	15	20	9	9
13 to 14	13	27	10	23	5	14
14 to 15	14	24	9	14	6	9

TABLE V[1]

MEDIAN YEARLY IMPROVEMENT IN GROSS SCORE FOR EACH AGE, TEST, AND SEX

Yearly Gain from Age	*1*		*2a*		*2b*		*2c*		*2bc*	
	B	*G*	*B*	*G*	*B*	*G*	*B*	*G*	*B*	*G*
9 to 10 .	6.00	20.67	16.25	16.50	8.75	16.50	18.75	20.83	25.83	28.75
10 to 11 .	14.67	17.33	10.00	15.00	12.50	17.50	22.50	10.00	22.50	26.00
11 to 12 .	10.67	6.50	10.00	11.50	13.00	7.92	27.50	16.25	25.00	13.13
12 to 13 .	3.00	14.00	11.25	14.29	11.00	10.00	30.00	17.50	18.33	17.50
13 to 14 .	28.33	18.50	17.50	11.25	11.25	12.92	27.50	27.50	25.83	22.08
14 to 15 .	10.00	16.00	11.25	12.50	8.75	14.29	12.50	20.00	13.33	21.25
	3		*4*		*5a*		*5b*		*5ab*	
9 to 10 .	5.00	5.00	22.50	16.25	4.50	7.33	4.00	6.67	4.50	7.20
10 to 11 .	3.33	8.67	31.25	20.00	5.00	4.67	7.33	6.33	5.00	5.33
11 to 12 .	4.33	5.00	15.00	13.50	4.33	8.25	3.67	4.75	3.00	5.75
12 to 13 .	3.00	4.00	10.00	12.50	4.25	4.71	5.33	3.50	4.00	4.33
13 to 14 .	4.67	3.56	10.83	6.50	7.67	5.25	2.33	5.60	4.14	4.80
14 to 15 .	5.00	1.67	6.67	10.00	4.50	5.00	5.75	10.00	6.00	2.00
	6		*7*		*8*		*9*		*10*	
9 to 10 .	31.50	24.75	2.88	1.25	.650	.950	3.38	3.50	5.00	1.88
10 to 11 .	21.75	15.00	2.25	1.50	.500	.450	2.40	1.70	3.25	2.50
11 to 12 .	11.25	10.13	1.33	2.15	.633	.600	2.17	2.19	1.88	2.50
12 to 13 .	4.88	9.00	2.63	1.83	.700	.340	1.90	1.38	1.50	3.75
13 to 14 .	10.50	6.75	1.33	1.58	.350	.783	1.00	1.79	7.50	3.00
14 to 15 .	7.50	10.00	1.42	1.67	.700	.600	1.13	2.33	1.00	1.25
	11		*12*		*13*		*14*		*15*	
9 to 10 .	3.50	2.25	5.50	5.25	2.00	0.75	7.50	6.75	28.75	18.75
10 to 11 .	2.50	2.50	2.75	2.25	1.67	0.00	10.00	10.00	26.67	27.00
11 to 12 .	2.75	1.90	2.67	2.50	0.00	1.20	9.00	9.38	27.50	19.38
12 to 13 .	1.50	1.50	1.00	2.00	1.00	2.20	7.00	6.75	19.00	25.00
13 to 14 .	1.38	1.70	.50	2.10	2.00	2.00	1.50	7.69	22.50	28.75
14 to 15 .	2.00	1.00	1.00	3.50	1.00	1.67	7.50	4.88	30.00	20.00
	16		*17*		*18*					
9 to 10 .	9.33	6.25	2.38	2.75	.750	.800				
10 to 11 .	5.57	3.88	1.50	1.50	.767	.700				
11 to 12 .	3.67	3.38	2.00	1.44	.533	.438				
12 to 13 .	3.25	3.00	2.67	1.25	.500	.400				
13 to 14 .	3.67	2.73	1.75	1.42	.440	.417				
14 to 15 .	2.00	2.00	1.00	1.60	.200	.367				

[1] This table should be read as follows: In *Test 1* boys made a median gain in gross score of 6.00 from age nine (i. e., 9.0 to 9.9) to age ten (i. e., 10.0 to 10.9), etc.

Only a very rough idea of the course of improvement from one age to another can be obtained from Table V. In order to compare the results of the different tests with one another, in order to combine them into similar groups upon various bases of classification, and in order to compare my results with those of other investigators, it is necessary to employ some means that will overcome the effect of different-sized units in the different tests and of different numbers of persons tested in different experiments. The size of units presents itself concretely as follows: Is an improvement of 21.75 problems on the Woody scale more or less than an improvement of 5.25 problems on the Courtis arithmetic tests? It is unnecessary to go into any discussion of the various methods which are possible. The method used by Norsworthy (1906), recommended by her and by Thorndike, Woodworth (1912), Sleight, and others, is the method which is quite commonly used in giving careful statistical treatment to educational and psychological data. This method, which seeks to equalize units of different tests and to render data from different groups comparable, employs the procedure of dividing gross score differences of various kinds by the respective variabilities of the tests, groups, etc. Any measure of variability, average deviation, median deviation, semi-interquartile range, or standard deviation, may be used. On the whole the use of the standard deviation is probably better than that of other measures of dispersion.

With my data the problem is to render different tests comparable, and to compare gains at different ages. I have not, however, divided the gross gains in each test at each age by the respective variabilities for each age and test, but have used the average of the standard deviations of ages eleven, twelve, and thirteen. We may think of gain at different ages in two ways at least: (1) Gain in relation to whatever ability, training, etc., the child at any age possesses; i. e., gain as a fraction of what he already is, or has. (2) Gain in relation to some more or less constant, objective thing, by which we can say the child from nine to ten improves 1.2 as much as from fourteen to fifteen, and 1.1 as much as from eleven to twelve, and mean this constant, absolute sort of thing, rather than the kind of gain implied in (1). It is for the purpose of finding out something about gain or improvement in this second sense that we have chosen to divide the different gains by a constant in each test and for each sex—the

TABLE VI[2]

YEARLY SIGMA GAINS IN EACH TEST FOR EACH AGE AND SEX—DATA OF TABLE V DIVIDED IN EACH CASE BY THE APPROPRIATE AVERAGE S. D.

Yearly Gain from Age	*1*		*2a*		*2b*		*2c*	
	B	*G*	*B*	*G*	*B*	*G*	*B*	*G*
9 to 10 . .	.213	.792	1.071	.673	.524	.731	.653	.786
10 to 11 . .	.669	.664	.658	.611	.749	.775	.783	.377
11 to 12 . .	.487	.249	.658	.469	.719	.346	.958	.613
12 to 13 . .	.106	.537	.741	.583	.659	.438	1.054	.660
13 to 14 . .	1.293	.709	1.153	.458	.674	.565	.958	1.037
14 to 15 . .	.456	.613	.741	.509	.524	.625	.435	.754
	2bc		*3*		*4*		*5a*	
9 to 10 . .	1.080	1.026	.358	.370	.581	.440	.656	.866
10 to 11 . .	.941	.928	.239	.642	.807	.542	.729	.552
11 to 12 . .	1.046	.468	.310	.370	.387	.366	.631	.975
12 to 13 . .	.766	.625	.215	.296	.258	.338	.619	.557
13 to 14 . .	1.080	.788	.335	.263	.280	.176	1.118	.621
14 to 15 . .	.557	.758	.358	.123	.172	.271	.656	.591
	5b		*5ab*		*6*		*7*	
9 to 10 . .	.606	.736	.700	.862	1.852	1.369	.927	.484
10 to 11 . .	1.111	.698	.778	.638	1.279	.830	.723	.581
11 to 12 . .	.556	.524	.466	.689	.661	.560	.427	.833
12 to 13 . .	.807	.386	.622	.519	.287	.492	.845	.709
13 to 14 . .	.353	.618	.644	.575	.617	.373	.427	.612
14 to 15 . .	.871	.000	.932	.240	.441	.553	.456	.647
	8		*9*		*10*		*11*	
9 to 10 . .	.661	.896	.875	.988	1.587	.610	1.194	.783
10 to 11 . .	.501	.424	.621	.480	1.031	.811	.853	.871
11 to 12 . .	.634	.566	.562	.618	.597	.811	.938	.662
12 to 13 . .	.702	.320	.492	.389	.476	1.217	.511	.522
13 to 14 . .	.351	.737	.259	.505	2.381	.974	.470	.592
14 to 15 . .	.702	.566	.292	.658	.317	.405	.682	.348
	12		*13*		*14*		*15*	
9 to 10 . .	1.361	1.535	−.246	.087	.754	.528	1.257	.633
10 to 11 . .	.680	.657	.206	.000	1.005	.783	1.166	.912
11 to 12 . .	.660	.760	.000	−.139	.904	.726	1.202	.654
12 to 13 . .	.247	.584	.123	.255	.704	.528	.831	.844
13 to 14 . .	.122	.614	−.246	.232	.150	.602	.984	.971
14 to 15 . .	.247	1.022	−.123	−.193	.754	.374	1.312	.675

[2] This table reads: In *Test 1* boys from nine to ten improved .213 of the average S.D. of *Test 1* of boys of ages eleven, twelve, and thirteen.

TABLE VI—*Continued*

Gain from	16		17		18			
9 to 10 . .	1.476	1.036	.944	1.191	.974	1.230		
10 to 11 . .	.881	.645	.595	.649	.996	1.076		
11 to 12 . .	.580	.560	.793	.623	.692	.673		
12 to 13 . .	.514	.497	1.059	.541	.649	.607		
13 to 14 . .	.580	.452	.694	.614	.571	.641		
14 to 15 . .	.316	.331	.396	.692	.259	.564		

average of the eleven-, twelve-, and thirteen-year S.D.'s of each test for each sex.

The data of Table V have, therefore, been divided by the appropriate average S.D.'s; the results are given in Table VI. These results are now comparable, and we can examine this table to see the changes which have taken place with the group tested, from one age to another, but only in so far as we are safe in saying that the group has been truly tested. An inspection of Table VI shows the great variation in the amount of gain in the different tests at different ages.

Much time could be spent developing more or less fantastic theories to fit the data of Table VI; e. g., if one compared Test *2a* with Test *2b*, the question at once arises, "How will we harmonize the great increase in improvement of the boys in Test *2a* from thirteen to fourteen over that from twelve to thirteen, with practically no increase at the same time in Test *2b?*" It could, of course, be said that the habits being formed in handwriting recitation practice (the thing tested in Test *2b*, become so firmly fixed by age thirteen that they carry over into ordinary written work to a greater extent during the following year in than previous years, and so bring about a greater improvement in the quality of the handwriting in ordinary written work from thirteen to fourteen. This may or may not be true. My data do not seem to give valid grounds for such a conclusion. Again, comparing Test *5b* Courtis, rights, with Test *6*, Woody arithmetic, let us note the discrepancy in rate of gain from nine–ten to ten–eleven in the two tests. How do we account for the increase in rate in the one test and for the decrease in rate in the other? The same people were tested in both tests under as nearly the same conditions as we could probablv

obtain. Here again, we might speculate over the difficulty of the problems in the two tests, or the length of time required in relation to attention, etc. And so on, with all the tests.

I have compared the curves in the different tests (not given here)[3] by superimposition, and from doing this, as well as for other reasons, given later, believe our best interpretation of the data must be sought in another direction. To interpret directly from the results of single tests, most of them given but once in any spring (and hence not as reliable as if two tests of equal difficulty were given a week apart), and all of them given to a comparatively small number of children of each age and sex, is obviously unsound, even though often done. The unreliability due to few children tested can be seen in the even-numbered columns of Table I. I have computed the median deviations of the gains in each test at each age for each sex. These median deviations have been divided by the appropriate average S.D.'s; the results have been analyzed; these P.E.'s show clearly that we must group our data in some way to enable us to place more reliance upon it.

Accordingly four bases of classification have been chosen, so that by grouping the results of the tests in these four ways all of the tests will be divided into a few large groups. This has the effect, in part, of giving a particular test twice; i. e., the different tests which belong to one of these large groups, when taken together, tend to give a more reliable result.

The following bases of classification have been chosen:

1. Similar Functions.
   a. Tests of simpler or lower mental functions.
   b. Tests of memory functions.
   c. Tests of higher or more complex functions.
   d. Tests of informational functions.
2. Presence or Absence of High Scores.
   a. Tests in which practically no high scores are made.
   b. Tests in which some very high scores are made.
3. Influence of School Instruction.
   a. Tests of functions much influenced by school instruction.
   b. Tests of functions little influenced by school instruction.

[3] Wherever reference is made to graphs or tables as not being given here, it means they are given in the original manuscript copy on file at Teachers College, Columbia University.

4. Ability Required to Make Initial Score.
   a. Tests requiring much ability to make an initial score.
   b. Tests upon which an initial score is easy to make.

This chapter should, then, seek to answer two broad questions: (1) What changes are revealed at the different ages in the tests when classified in this fourfold way? (2) What light do the data throw upon the different theories and opinions as to mental development with age?

Similar Functions. The tests have been divided among the four groups of similar functions as follows:

1. Simpler or lower mental functions: Test *1*, number checking; and tests *2a*, *2b*, and *2c*, the handwriting tests. 2. Memory functions: Tests *11* and *12*, immediate auditory memory, concrete and abstract; and Test *13*, memory for the English equivalents of Italian words. 3. Higher or more complex functions: Test *8*, composition; test *9*, opposites; test *10*, directions; test *14*, substitution; digit-geometrical forms; test *15*, substitution; letter-digit; test *16*, the part of Omnibus test used; test *17*, Trabue Language Completion; test *18*, Thorndike Reading, Alpha 2—the understanding of sentences.

TABLE VII

Average Gains, Four Groups of Similar Functions, in Terms of the Average S.D. of Ages Eleven, Twelve and Thirteen; for Boys and Girls

Ages	*Simpler*		*Memory*		*Higher*		*Informational*	
	B	*G*	*B*	*G*	*B*	*G*	*B*	*G*
9 to 10 . .	.615	.745	.770	.802	1.013	.951	1.034	.806
10 to 11 . .	.714	.607	.580	.509	.845	.760	.875	.675
11 to 12 . .	.705	.419	.532	.428	.726	.650	.507	.573
12 to 13 . .	.640	.554	.294	.454	.675	.589	.434	.467
13 to 14 . .	1.019	.692	.095	.479	.678	.683	.502	.403
14 to 15 . .	.539	.625	.269	.392	.595	.542	.439	.407

4. Informational functions: Test *3*, spelling-columns Q, S, and U, of the Ayres scale; test *4*, Thorndike Reading A2 and B—visual vocabulary; tests *5a* and *5b*, Courtis arithmetic, form B; test *6*, Woody arithmetic—series A; test *7*, Stone reasoning.

But grouping tests as informational, does not imply that they do not test the higher functions. Division problems and the problems of the Stone reasoning test do test what we regard as higher or complex functions. In the same way increase in vocabulary is a mark of developing intellectual grasp, at least, up to a certain extent. The tests included under this heading were chosen so as to have several tests more or less similar, in the group with the spelling, and the arithmetic problems in subtraction, etc.

As already noted, the data of Table VI are comparable for the different tests. I have accordingly combined them into these four groups by averaging the S.D. gains of Table VI for each age and sex. This gives Table VII.

Let us take up these groups of functions in order. What changes are shown by the tests of the simpler or lower mental functions?

2. RATE OF IMPROVEMENT IN SIMPLER FUNCTIONS

An examination of the data of Table VII shows that the amount of gain for boys at the different ages was about the same, with a decided increase in the amount at thirteen–fourteen. The gains for the girls show a less amount of gain at eleven–twelve than at any other period. While these figures are now comparable with each other, and we can say that in the tests given, these children made median gains that bear the relationships shown by the figures of Table VII, yet an examination of the data of Table VIII (in which

TABLE VIII

P. E. OF YEARLY GAINS (IN TERMS OF THE S.D.) FOR EACH AGE AND SEX IN EACH GROUP OF THE SIMILAR FUNCTIONS

Ages	*Simpler*		*Memory*		*Higher*		*Informational*	
	B	*G*	*B*	*G*	*B*	*G*	*B*	*G*
9 to 10 . .	.437	.465	1.160	1.228	.422	.583	.466	.398
10 to 11 . .	.632	.681	.730	.804	.558	.558	.391	.420
11 to 12 . .	.492	.369	.564	.775	.444	.436	.427	.355
12 to 13 . .	.490	.468	.761	.545	.547	.534	.337	.323
13 to 14 . .	.598	.472	.610	.651	.508	.520	.294	.327
14 to 15 . .	.616	.458	.520	.727	.625	.550	.390	.427

are given the median deviations in terms of S.D. of the different groups of tests) tells us that the ups and downs shown by the figures of Table VII for simpler functions cannot be regarded as absolutely representative even of the group tested. On account of this fact and in view of the errors of sampling it seems that the data give evidence of a steady rate of improvement for both boys and girls at all ages from nine to fifteen; that this improvement is positive at all ages and is on the whole probably about .6 of the average standard deviation (in these tests) of ages eleven, twelve and thirteen. In Fig. 8 I have shown the curves of changes at these ages. In plotting the changes I have used the same distance for .5 S.D. as for one year. This has been done because the gains from one year to the next, as shown by the differences between the average

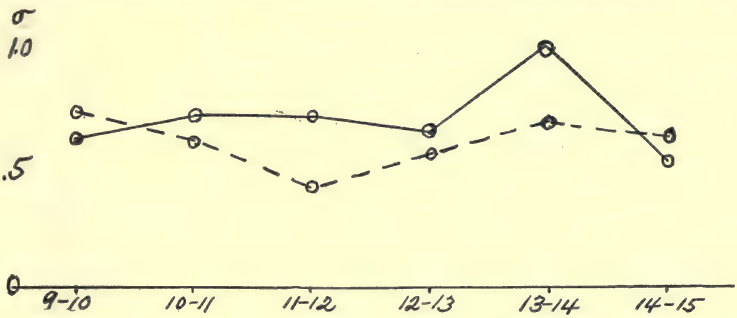

Fig. 8. S.D. Gains in Simpler Functions
Boys ———— *Girls* — — — —

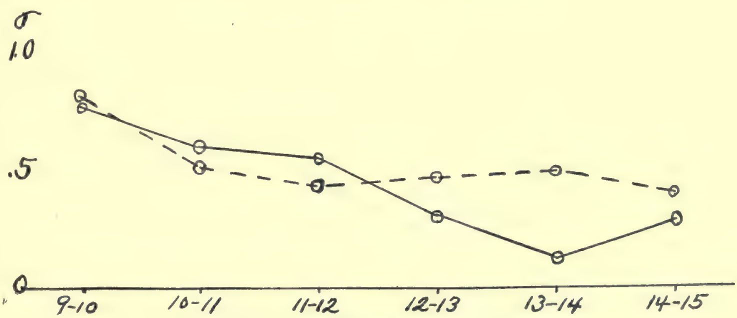

Fig. 9. S.D. Gains in Memory Functions
Boys ———— *Girls* — — — —

Minnesota Re-Test Data

of consecutive years in Table I, are on the whole about .5 S.D. and because the gains as shown by Table VII are approximately .5 S.D. Any other scale would have the effect either of accentuating unduly the ups and downs in the gains from one year to another, or of smoothing them out unduly. Using as the unit of gain for one year the same unit as for one year of age, seems to be the best procedure. The two noteworthy departures from a smooth curve in Fig. 8 are (1) at thirteen–fourteen for boys and (2) at eleven–twelve for girls.

It will be seen from Table VII and Fig. 8 that for both boys and girls the gains from nine to twelve are slightly less than from twelve to fifteen, though the small difference is probably a chance difference and of no significance. If we combine these gains into two-year periods, we find that for boys from nine to eleven, and from eleven to thirteen, the gains are equal, and that the gains of these two periods are each slightly less than those from thirteen to fifteen; for girls the gains for the two periods, nine to eleven, and thirteen to fifteen, are equal to each other; the gains from eleven to thirteen are about .4 S.D. less than those of either of the other two periods. The P.E.'s of the gains for these times (Table VIII) are large enough to make one skeptical of attaching significance to these differences.

3. RATE OF IMPROVEMENT IN MEMORY FUNCTIONS

In the case of the memory functions (Table VII) the results show for both boys and girls at all ages positive gains; for the boys the rate of gain, as revealed by the tests given, decreases from nine to fourteen, and increases from fourteen to fifteen. The amount of gain from nine to twelve is shown to be nearly three times the amount from twelve to fifteen. If we consider the gains by two-year periods we have gains for the three periods beginning at age nine, in the ratio of 13, 8, and 4. These differences are large enough to be significant. In the case of the girls the gains from nine to twelve are about one-third more than from twelve to fifteen. Taking two-year spans, we find these children in these tests making, from nine to eleven, from eleven to thirteen, and from thirteen to fifteen, S.D. gains which are in the ratio of 13, 9, and 9. The curves showing the gains in the memory functions are given in Fig. 9 (page 45). Here the drop in rate at the second age-period from that of the first is shown; likewise the constant decrease in the boys' rate till fourteen.

If we reject Test *13*, memory for English equivalents of Italian words, on the ground that the three tests of any one year were not of the same difficulty as those of either of the other two years, we get the results shown in Table IX.

TABLE IX

Showing the Yearly Gains in the Two Memory Tests, Tests *11* and *12*, Expressed in Terms of S.D.

Age	*9 to 10*	*10 to 11*	*11 to 12*	*12 to 13*	*13 to 14*	*14 to 15*
Boys	1.278	.767	.799	.379	.266	.465
Girls	1.159	.764	.711	.553	.603	.735

From Table IX it will be seen that for the boys the rate of gain, though positive at all ages, still decreases from nine to fourteen, increasing from fourteen to fifteen, while for the girls the rate decreases until thirteen or fourteen and then increases slightly. From nine to twelve the boys gain 2.5 times as much as from twelve to fifteen, while the girls gain 1.4 times as much; i. e., the ratio of first three years' gain to last three years' gain is about the same when the Italian vocabulary test is included as when it is omitted from the memory functions. Approximately the same thing is seen to be true when we group the gains by two-year periods.

To the extent that grade reached (in a carefully graded school) is an index of ability, and to the extent that the memory functions, tested by Tests *11*, *12*, and *13*, may be regarded as closely related to superior ability as thus measured by grade reached, to this extent are we justified in regarding the large gain made by both boys and girls from nine to ten as too high. Attention has already been called to the skew age-grade distributions for ages nine and ten (Figs. 1-a to 2-b). The data of Table VII seem to support as tentative conclusions regarding the rate of growth as tested by these three tests the following: For both sexes the ability which we call memory increases from nine to fifteen—at each year the child possesses more of this ability than he possessed the preceding year; for boys the rate of increase probably remains about constant from nine to twelve, decreasing the two following years, and probably increasing some from fourteen to fifteen; for girls the rate is probably very nearly constant throughout the six years, with an exception possibly in a decreased rate at fourteen–fifteen.

A comparison of Figs. 8 and 9 at once raises the question—how does it happen that boys from thirteen to fourteen make such a spurt in the rate of gain in the simpler functions while in the tests of memory functions they make such a slump at the same time? This question will be taken up later when we compare the data of this experiment with those of other investigations.

4. RATE OF IMPROVEMENT IN HIGHER AND INFORMATIONAL FUNCTIONS

The data of Table VII for higher or complex functions and for informational functions have been weighted as follows: In the former group all tests have been given a weight of one, except composition (weight, two) and Thorndike Reading, Alpha 2, the understanding of sentences (weight, three); in the group of informational functions all tests have been weighted as one each, except Woody arithmetic (weight, two); Courtis arithmetic, attempts, Test *5a*, and rights, Test *5b*, have been counted each as one-half; i. e., Courtis arithmetic has been given a weight of one. It has seemed desirable to give weights because the tests have different values in measuring. For example, while the opposites test is in itself a good test of higher functions, yet it probably does not measure higher functions, in the two minutes of its duration, to the same extent as a fifteen-minute composition test or a twenty-five- or thirty-minute test of ability to understand sentences. The weights assigned are meant to be only approximate since it would be practically impossible to assign accurate weights without knowing much more about just what the tests measure, and without

TABLE X

Showing the Yearly Gains in Tests of Higher and Informational Functions in Terms of the S. D., Each Test Being Given a Weight of One

Ages	*9–10*	*10–11*	*11–12*	*12–13*	*13–14*	*14–15*
			Higher Functions			
Boys	1.066	.850	.746	.679	.746	.544
Girls	.889	.723	.654	.618	.687	.533
			Informational Functions			
Boys	.830	.814	.495	.505	.522	.492
Girls	.711	.641	.605	.463	.444	.358

an expenditure of time out of all proportion to the advantage coming from the probably greater accuracy.

The data have been combined into these two groups of functions also by weighting each test as one. The results are given here for any one who may have valid grounds for objecting to the weights I have given.

The effect of using equal weights for all tests of higher and informational functions is seen by comparing data of Table VII and Table X. In the complex or higher functions it is seen to be for boys a slight increase in the rate of gain at nine to ten, and at thirteen to fourteen, and a slight drop at fourteen to fifteen, from the rates obtained by using the weights used in compiling Table VII; for girls the effect is a slight decrease at nine to ten, and at ten to eleven, and a slight increase at twelve to thirteen. Unequal weighting of the tests of higher functions (as I have weighted them) does not make any significant differences in the results.

In the case of the informational functions the weighting of the Woody arithmetic as two, does make more noticeable differences, —.2 S.D. for boys and .1 S.D. for girls at nine to ten, being the more significant ones. But the Woody scale, on account of its gradation of problems according to difficulty as well as from the longer time for its performance, should be given more weight than the Courtis, or the other tests, of this group.

Figs. 10 and 11 (page 50) show the changes in these two groups of functions. There is an interesting similarity in the curves. Chance differences may easily account for the small divergences shown in the general trend of the curves. The height of the curves from the base-line, i. e., the amount of gain, in the later years is lower than in the earlier years; this is true of both groups of functions.

Referring to Table VII and Fig. 10 we note that in the case of the higher mental functions there is substantial positive improvement at all ages for both boys and girls. There is a decrease, however, in the rate of improvement from nine until thirteen for both boys and girls; the following year the boys' rate remains constant, while that of the girls increases some; both decline from fourteen to fifteen. If we group the gains by three-year periods we find that both boys and girls gain from nine to twelve one-third more than they gain from twelve to fifteen: by two-year

periods we find the boys' improvements for the periods, nine to eleven, eleven to thirteen, and thirteen to fifteen, are in the ratio of 9.5, 7, and 6.5, respectively; for the girls, the ratio is 8.5, 6, and 6.

The data of Table VII for the informational functions show positive improvement for both boys and girls at all ages. The

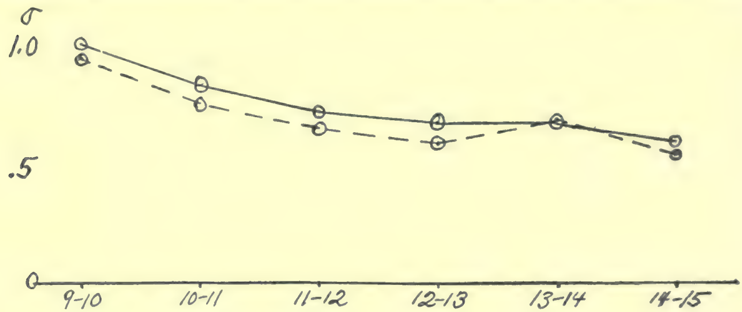

FIG. 10. S.D. GAINS IN HIGHER (OR COMPLEX) FUNCTIONS
Boys ———— *Girls* — — — —

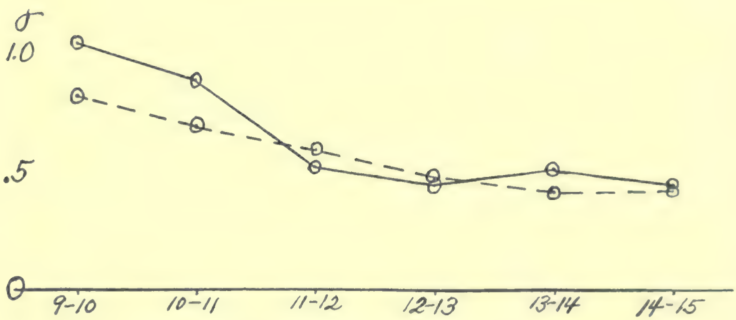

FIG. 11. S.D. GAINS IN INFORMATIONAL FUNCTIONS
Boys ———— *Girls* — — — —
Minnesota Re-Test Data

boys' rate of improvement decreases rapidly the first two years, remaining practically constant during the next four years; the girls' rate decreases rapidly the first year, less rapidly the next year, and remains at a nearly constant level from twelve to fifteen. The data show the boys gain from nine to twelve about one and a half times as much as during the next three years; the girls gain

during this nine-to-twelve period one and two-thirds as much as from twelve to fifteen. When we consider two-year periods, we find the boys gaining from nine to eleven, eleven to thirteen, and thirteen to fifteen, amounts which are in the ratio of 2, 1, and 1; the girls' gains during the same times are amounts in the ratio of 7.5, 5, and 4.

Besides the similarity of the curves in Figs. 10 and 11, it should be observed that the curves for the informational functions are much lower during the last four years than the curves for the higher mental functions; this difference is not to be accounted for by chance. The distributions of the scores in the informational tests at the different ages (these distributions were made to compute the averages and standard deviations, but are not given here) show that in three of these tests some of the children from eleven to fifteen made perfect or very nearly perfect scores in the tests and so were not fully tested. This is true in enough cases at the later ages to account for much of the decrease in the amount or rate of improvement. Had harder spelling words, more difficult reading words (visual vocabulary tests to difficulty 10 were given) and more problems, or more difficult problems in the arithmetic tests (Woody Scale A) been used, there is every reason to believe the curves of Fig. 11 would be as high at the later ages as those of Fig. 10.

What was said about the greater gain in memory in the earlier years being due to selection, is equally true here. We do not need any theory of pre-adolescent spurt at nine or ten to account for the greater gains made at these times. Selection (as shown by Figs. 1-a to 2-b) has cut off nine- and ten-year-olds of less ability to an extent that easily accounts for the greater gains at these times. Dewey, Child and Ruml (1920) from more than 3000 New York City school children made a random sampling of fifty boys and fifty girls of each of five ages. Of the fifty boys of age nine 17, or 34 per cent, were in second or third grade, and 19, or 38 per cent, were in the beginning fourth; of the nine-year-old girls 17, or 34 per cent, were below fourth grade, and 23, or 46 per cent, were in the beginning fourth. Of the ten-year-old boys 4, or 8 per cent, were below the fourth grade and 4, or 8 per cent, were in the beginning fourth; of the girls who were ten years old, 8, or 16 per cent, were below the fourth grade and 5, or 10 per cent, were in

the beginning fourth. In contrast with this lower end of their grade distribution of nine- and ten-year-olds, it should be noted that of the children tested in this investigation not one of the youngest was below advanced fourth grade.

At the other extreme of ages we find selection cutting off some children of superior ability. Thorndike (1914, p. 195) and Strayer and Thorndike (1913, p. 4) give data which indicate that limiting the testing of fourteen- and fifteen-year-olds to those who were not beyond the ninth grade, eliminates some children of superior ability. Figs. 4-b, 5-b, 7-a, and 7-b show how some children of greater ability were not tested at these ages. All this upon the basis of grade reached in school as a measure of ability.

All these facts taken together give grounds for the tentative conclusion that the rate of improvement at all these ages is very nearly constant and that it probably is about .6 or .7 S.D.

5. RATE OF IMPROVEMENT SHOWN IN TESTS GROUPED UPON OTHER BASES OF CLASSIFICATION

As a further analysis of the data on rates of improvement the tests were grouped in the three following ways: (1) As to presence or absence of very high scores; (2) as to influence of school instruction; (3) as to ability required to make an initial score. Graphs were drawn to show the rates of improvement for each of these groupings. These tables and graphs (not printed here) show the following very close resemblance between the curves: (1) Complex functions with (*a*) tests in which very high scores were absent, (*b*) tests much influenced by school instruction, and (*c*) tests in which making an initial score required much ability. (2) Informational functions with (*a*) tests in which some perfect or very high scores were made, (*b*) tests little influenced by school instruction, and (*c*) tests in which making an initial score required comparatively little ability. Furthermore, these two sets of curves are themselves not at all dissimilar.

6. CONCLUSIONS AS TO RATE OF IMPROVEMENT

What light, then, do Tables VII and VIII and Figs. 8 to 11, throw upon the course of mental development from ages nine to fifteen? Selection at certain ages has already been noted as operative to raise the curves at the earlier ages, and to lower them

slightly at fourteen and fifteen, especially in the case of those functions highly correlated with intelligence; the median deviations (Table VIII) of the gains have been referred to as probably explanatory of certain irregularities; the presence of perfect or very high scores at certain ages in some of the tests has been noted; while it must not be overlooked that a given gain or improvement in gross score from a very high score represents more absolute improvement than the same gain from a lower initial score. All of these considerations in connection with the smoothing of the curves (found in Chapter VI) when the number of cases and number of of tests are increased, seem to warrant the conclusion that not only are the gains positive at all ages between nine and fifteen for both sexes, but also the rate of improvement is probably best represented by a straight line whose slope is probably slightly negative.

7. SEX DIFFERENCES

Referring to Table I we can compare the boys' average scores in each of the tests at each age with those of the girls. It will be observed from such a comparison that on the whole the girls' averages are higher than those of the boys. More specifically, the girls' averages exceed the boys' averages at all ages in the following nine tests: number checking, handwriting quality in ordinary written work and in handwriting tests, spelling, Courtis arithmetic attempts and rights, composition, Woodworth-Wells substitution, and letter-digit substitution. In the other tests the girls exceed the boys with exceptions as noted: in handwriting speed, except at thirteen; visual vocabulary, all ages except twelve; Woody arithmetic, from nine to twelve, the boys excelling from twelve to fifteen. In Stone reasoning, the girls exceed the boys' averages at nine and ten only; in the opposites test the girls make better scores except at nine, thirteen, and fifteen; in the directions test the girls are superior to the boys except at thirteen, when their average is the same as that of the boys, and at fourteen when the boys' average is more. In concrete memory the boys excel only at nine, while in abstract memory they excel only at thirteen; in memory for Italian words the girls excel at all ages except nine, while in the Omnibus the boys excel at all ages except nine. In language completion and reading, Alpha 2, the girls make higher scores except at thirteen.

The best single quantity to use in comparing two groups is the per cent of the one group equalling or exceeding the median of the other group. I have accordingly found the per cent of boys of each age equalling or exceeding in each test the median of the girls of the same age in the same test. These per cents are shown in Table III.

More than fifty per cent of the boys reach or exceed the median of the girls as follows:

At age nine: In number checking (57.1 per cent), Courtis arithmetic, rights (71.4 per cent), Woody arithmetic (77.1 per cent), concrete memory (57.1 per cent), abstract memory (57.1 per cent), Italian words (85.7 per cent), and Omnibus (71.4 per cent).

At age ten: In memory, abstract (53.1 per cent), and Omnibus (58.3); in memory for Italian words just fifty per cent of the boys reach or exceed the median score of the girls.

At age eleven: In opposites (52.8 per cent).

At age twelve: In the visual vocabulary (59.4 per cent), Stone reasoning (54.9 per cent), opposites (57.1 per cent), and abstract memory (52.5 per cent).

At age thirteen: In visual vocabulary (58.3 per cent), Stone reasoning (60.0 per cent), opposites (66.6 per cent), abstract memory (53.3 per cent), and language completion (54.2 per cent); in Woody arithmetic and concrete memory just fifty per cent of the boys equal or exceed the girls' median.

At age fourteen: In visual vocabulary (54.2 per cent), Stone reasoning (56.2 per cent), opposites (75.0 per cent), directions (79.0 per cent), concrete memory (52.1 per cent), abstract memory (54.2 per cent), and language completion (52.1 per cent); in Woody arithmetic the boys' and girls' median is the same.

At age fifteen: In visual vocabulary (53.3 per cent), Woody arithmetic (66.6 per cent), Stone reasoning (55.5 per cent), opposites (66.6 per cent), concrete memory (53.3 per cent) and language completion (50.6 per cent).

The superiority of the girls, as indicated by the small per cent of boys equalling or exceeding their median scores, is noticeable. By running through the columns of Table III it will be observed that in number checking at eleven, twelve, and thirteen less than one-fifth of the boys reach the girls' median; in both of the quality of handwriting tests, after age nine less than one-sixth of the boys

do as well as the median girl; while at half of these ages less than one-tenth of the boys do as well as the fifty-percentile girl; in speed of handwriting and composition at five of the seven ages, in spelling at all ages, in directions and Woodworth-Wells substitution at half of the ages, and in letter-digit substitution at six of the seven ages, but one-third of the boys reach or exceed the median score of the girls; in visual vocabulary and reading Alpha 2, one-seventh of the nine-year-old boys reach the girls' median; in the Courtis arithmetic, after age nine about one-third to two-fifths of the boys make as good scores as the median girl; in opposites at age nine but 7 per cent of the boys do as well as the fifty-percentile girl.

In the Stone reasoning, visual vocabulary, and opposites the boys are clearly superior at the last four ages, whereas in number checking, handwriting, spelling, Courtis arithmetic, composition, Italian vocabulary, Woodworth-Wells substitution, Omnibus, and reading Alpha 2, the girls are just as clearly superior at practically all ages.

Tables V, VI, and VIII show the amount of improvement for boys and girls. A better idea of the rate of gain or improvement can be obtained from Figs. 8 to 11. From these it will be seen that in the case of the simpler functions the boys' rate is higher than that of the girls at all ages, except from nine to ten and from fourteen to fifteen; for memory, the girls' rate is higher except from ten to twelve; the rates of gain in the case of the complex or higher mental functions are very nearly the same for both boys and girls, the boys' rate being a little higher at all times except from thirteen to fourteen; in the case of the informational functions the boys' rate is higher than that of the girls except from eleven to thirteen, though the difference from thirteen to fifteen is very slight.

On the whole, the average rate of gain of the boys per year per test is practically the same as that of the girls—to be exact, it is .036 S.D. more.

It will be seen, however, from the P.E.'s *t.av.—obt.av.* (Table I) and from the P.E.'s of the gains (Table VIII) that any conclusions from these data as to any general sex differences, would be of exceedingly doubtful validity.

In the matter of rate of gain it could very well be urged that there are no sex differences shown.

VI

RATES OF GAIN SHOWN BY OTHER INVESTIGATIONS

RATES OF GAIN FROM COMBINATION OF OTHER DATA WITH MINNESOTA RE-TEST DATA

It has seemed desirable to compare my results with those of other quantitative investigations. However, available data on changes in mental traits from one age to another, determined by re-tests of the same individuals, are very meagre. It has been necessary, therefore, to compare my data with those of other investigators who have not re-tested the same individuals at intervals of a year or half-year, but who have tested the groups but once, or, if twice, at very short intervals, usually a week, to secure greater reliability. By such a method the changes from one age to another are determined by taking the differences between the central tendencies of the groups of persons of different ages. In making use of this material, it has been necessary for all these differences from one age to the next to be made comparable. In doing this I have followed the same procedure as in making my own data from different tests comparable; viz., by dividing the differences in gross score in the different tests at different ages by averages of the variabilities of ages eleven, twelve, and thirteen of the respective tests. The variability reported in these data is the standard deviation, average deviation, or semi-interquartile range, usually referred to as the Q; but all gains have finally been changed to the basis of standard-deviation gains. Pyle's data for 1920 give no variability. In order to use these results I have assumed that the variability in a test of the 1920 group is the same as that in the same test of the 1913 group. This is subject to some inaccuracy, but is not seriously in error when making test results comparable so as to combine them.

The standard deviation gains, shown by the data of Gilbert (1894), Pyle (1913, 1920), Bickersteth (1914–15), Dewey, Child and Ruml (1920), and Woolley (soon to be published), have been in each case averaged to form three groups of similar functions—simpler, memory, and higher or more complex.

In Tables XI and XV the data for simpler functions are given. For the present, consideration will be given to the gains between ages nine and fifteen. From nine to twelve Gilbert found boys making twice as much gain, and girls four times as much gain as from twelve to fifteen. Pyle in different tests of simpler functions also found the boys' rate from nine to twelve two times that from twelve to fifteen, while the girls' rate was the same for the two

TABLE XI

Average Yearly Gains in Tests of Simpler Functions, in Terms of the Standard Deviation

Ages	*Gilbert*		*Pyle (1913)*		*Bickersteth*		*Ox.*[1]	*Dewey, Child and Ruml*	
	B	*G*	*B*	*G*	*B*	*G*	*G*	*B*	*G*
8 to 9	.394	.198	.302	.474	. . .	. . .	.634	. . .	. . .
9 to 10	.438	.433	.242	.125	. . .	. . .	.428	.310	.417
10 to 11	.202	.279	.242	.344	.478	.410	.449	.350	.091
11 to 12	.317	.167	.330	.133	.211	.403	.291	.410	.201
12 to 13	.071	.098	−.085	.266	.412	−.035	.150	.211	.557
13 to 14	.240	.080	.443	.183	. . .	. . .	.382	. . .	. . .
14 to 15	.135	.020	.006	.157	. . .	. . .	.000	. . .	. . .
15 to 16	.130	.206	.070	.192	. . .	. . .	. . .	. . .	. . .
16 to 17	.222	.028	.322	.146	. . .	. . .	. . .	. . .	. . .
17 to 18	. . .	. . .	.686	.264	. . .	. . .	. . .	. . .	. . .

periods. Bickersteth found the girls from twelve to fifteen making a gain one-half that of the previous three years. Pyle's results for girls are in agreement with my own so far as the relative gains from nine to twelve and from twelve to fifteen are concerned. Comparison of Dewey, Child, and Ruml's results by two-year periods shows the boys' gains from nine to eleven equal to those from eleven to thirteen, and the girls' gains for this first period less than from eleven to thirteen. The results for boys are the same as shown by my data.

In all of these studies the gains are positive at all ages between

[1] "Ox." refers to data from tests of girls in the Oxford higher elementary schools.

nine and fifteen, with but two exceptions—Pyle's boys from twelve to thirteen, and Bickersteth's girls from twelve to thirteen making negative gains.

The curves (not printed here) showing the gains found in all of these investigations are very irregular, and indicate different rates of gains at different ages. Moreover, they are inconsistent with each other. Gilbert's curve might easily be taken as evidence of a two-year rhythm for boys. Such conclusions are to be avoided. The evidence is not sufficient to warrant them. A careful comparison of the data of Tables XI to XV will reveal enough disagreements (as to rates of gain at different ages in the same group of functions) to make one cautious about trying to conclude from any one study just what the real rate of improvement is. Thus Bickersteth finds the rate of improvement of simpler functions for the Yorkshire Dales girls to be not at all in agreement with the rate for the Oxford girls, yet the same tests were given to both groups and were repeated a week after the first testing so as to secure greater reliability.

TABLE XII

AVERAGE YEARLY GAINS IN TESTS OF MEMORY FUNCTIONS, IN TERMS OF THE STANDARD DEVIATION

Ages	*Gilbert*		*Pyle (1913)*		*Bickersteth*		*Ox.*[2]	*Dewey, Child, and Ruml*	
	B	*G*	*B*	*G*	*B*	*G*	*G*	*B*	*G*
8 to 9	.039	−.674	.276	.212	. . .	. . .	. . .	. . .	. . .
9 to 10	−.039	1.102	.266	.947	. . .	. . .	−.028	.253	.052
10 to 11	.314	.225	.409	−.086	. . .	. . .	.028	.236	.341
11 to 12	.184	.143	−.039	.278	. . .	. . .	−.028	−.080	.031
12 to 13	.443	.062	.121	.251	. . .	. . .	.223	.220	.231
13 to 14	−.274	.204	.394	.466	. . .	. . .	.195	. . .	. . .
14 to 15	−.118	.326	−.166	−.240	. . .	. . .	. . .	. . .	. . .
15 to 16	−.138	−.408	.557	.242	. . .	. . .	. . .	. . .	. . .
16 to 17	.157	.367	.224	−.402	. . .	. . .	. . .	. . .	. . .
17 to 18	. . .	. . .	.216	1.457	. . .	. . .	. . .	. . .	. . .

[2] "Ox." refers to data from tests of girls in the Oxford higher elementary schools.

TABLE XIII

AVERAGE YEARLY GAINS IN TESTS OF HIGHER FUNCTIONS, IN TERMS OF THE STANDARD DEVIATION

Ages	*Gilbert*		*Pyle (1913)*		*Bickersteth*		*Ox.*[3]	*Dewey, Child and Ruml*	
	B	*G*	*B*	*G*	*B*	*G*	*G*	*B*	*G*
8 to 9	.504	.216	.258	.250	...	...	.313	...	...
9 to 10	.648	.648	.259	.482	.503	.323	.314	.377	.174
10 to 11	.187	.389	.330	.173	.450	.224	.410	.318	.234
11 to 12	.029	.259	.125	.358	.207	.414	.209	.226	.097
12 to 13	.360	−.648	.434	.249	.394	.304	.174	−.025	.302
13 to 14	−.101	.864	.071	.252	...	...	.193	...	...
14 to 15	.807	.144	.453	.199	...	...	.226	...	...
15 to 16	−.058	−.072	.203	.217	...	...	...	...	...
16 to 17	.144	.504	.069	.366	...	...	...	...	...
17 to 18	...	...	.332	.117	...	...	...	...	...

TABLE XIV

SHOWING YEARLY GAINS IN MEMORY AND HIGHER FUNCTIONS IN TERMS OF STANDARD DEVIATION—PYLE (1920) DATA

Ages	*Memory*		*Higher*	
	B	*G*	*B*	*G*
8 to 9 . .	.198	.224	.292	.204
9 to 10 . .	.279	.151	.342	.390
10 to 11 . .	.235	.354	.218	.454
11 to 12 . .	.163	.234	.262	.403
12 to 13 . .	.069	.212	.258	.350
13 to 14 . .	.106	.093	.256	.241
14 to 15 . .	.159	.082	.271	.266
15 to 16 . .	−.014	.126	.207	.382
16 to 17 . .	.250	.098	.425	.155
17 to 18 . .	−.035	.019	.007	.169

[3] "Ox." refers to data from tests of girls in the Oxford higher elementary schools.

TABLE XV

SHOWING YEARLY GAINS IN SIMPLER, MEMORY AND HIGHER FUNCTIONS IN TERMS OF STANDARD DEVIATION—WOOLLEY RE-TEST DATA

Ages	*Simpler*		*Memory*		*Higher*	
	B	*G*	*B*	*G*	*B*	*G*
14 to 15	.723	.776	.340	.289	.390	.406
15 to 16	.097	.005	.511	.463	.160	.154
16 to 17	.146	.195	.114	.231	.021	.081
17 to 18	.408	.440	.028	.057	−.001	.110

Tables XII, XIV, and XV set forth the gains in memory functions. It will be noticed that Gilbert quite frequently finds the rate of gain to be negative. His data include one memory test—the estimation of a length of time equal to a two-minute period. The boys' gain from nine to twelve was nine times that from twelve to fifteen, but it is doubtful if any one would insist that such figures represent the course of improvement of memory, or even of time-memory.

The girls' rate was more than twice as great during the first three-year period as during the second. Pyle (1913) found negative gains for both boys and girls at one-third of the one-year periods between nine and fifteen. But in his 1920 data he finds with the larger groups no negative gains at any age between nine and fifteen; furthermore the gains from year to year are more regular than with the smaller 1913 group. This change toward greater regularity of gain from year to year, as we increase either the number of tests or the number of children tested, or especially as we increase both—this concomitant greater regularity of yearly rate is significant. However, the ratios of the total gain from nine to twelve to the total gain from twelve to fifteen, are the same practically in 1920 as in 1913—being about two to one.

Bickersteth (Oxford girls) found no gain from nine to twelve in memory for related words; but these results are not conclusive because at every age some children made perfect scores. Dewey, Child, and Ruml found the boys' gains from nine to eleven more than three times as great as during the next two years, while the

girls gained from nine to eleven one and a half times as much as from eleven to thirteen.

The general evenness of Pyle's (1920) curves (not given here) between nine and fifteen is quite noteworthy. It is in marked contrast with Norsworthy's gains in memory for related and unrelated words, and Smedley's data for growth of memory of digits.

Tables XIII, XIV, and XV give the data for the higher mental functions. Gilbert's data represent one test, reaction with discrimination and choice, and show very great variations from year to year. Gilbert found negative gains for girls at twelve–thirteen and for boys at thirteen–fourteen. From nine to twelve boys gain two-thirds as much as from twelve to fifteen, while girls gain three times as much. Pyle's data for 1913 show positive gains at all ages but the rate from year to year is not even or constant; from nine to twelve, boys make an improvement about 70 per cent of that from twelve to fifteen; girls make nearly one and a half times as great gain from nine to twelve as from twelve to fifteen. The 1920 data, as compared with that of 1913, show the same greater evenness from year to year as in the case of memory. The boys' gains from twelve to fifteen are equal to those from nine to twelve; the girls' gains during the nine–twelve period are one and a half times as great as during the twelve–fifteen period. It should be noted here that both boys and girls make slightly smaller gains from fifteen to eighteen than from twelve to fifteen.

Bickersteth found boys from nine to eleven gaining 50 per cent more than from eleven to thirteen, while the girls gained about one-third more from eleven to thirteen than during the two previous years. Oxford girls from nine to twelve make 50 per cent greater gains from twelve to fifteen. Comparison of the Yorkshire Dales girls with the Oxford girls shows that from nine to eleven the former gain nearly two times as much as from eleven to thirteen, while the latter gain but 80 per cent as much from nine to eleven as from eleven to thirteen. Bickersteth's gains at all ages are positive. Dewey, Child, and Ruml found positive gains at all ages except from twelve to thirteen for boys. From nine to eleven the boys gain more than three times as much as from eleven to thirteen; the girls' improvement is the same for both periods.

The curves, showing the rates of improvement found in each of these investigations, are not given here; they show the effect of

increasing the number of subjects and tests by a greater smoothness of the curves, and by the nearly constant rate of improvement from eight or nine to fifteen or sixteen; but increasing the number of subjects tested and increasing the number of tests given, is, other things being equal, getting more adequate measures of mental traits at different ages.

Comparing all these data with my own, we see that the S. D. gains in the latter case are much greater than in the former; or, more exactly, they are from 1.5 to 6.9 times as much. It is reasonable to assume that the amount of growth from nine to fifteen is approximately the same for all the groups of children tested by these investigations, and that the differences in the size of the S. D. gains are largely due to the different tests used to measure the functions and to the possible masking of some of the changes which is involved in taking the differences of the central tendencies of different ages as the amount of growth from year to year. Proceeding upon this assumption, I have put the total gains from nine to fifteen of the children I tested, equal to the total gains found in each of these investigations in the same functions for the same ages. The gains for each year have then been parcelled out so that the relative gain from year to year has been preserved, and the total gain from nine to fifteen is equal in all cases to the gain shown by my group. Where data are given for periods of time less than six years, the gains for the shorter period are put equal to the gains made by the Minnesota re-test group for the same years, and then parcelled out to each year of the shorter period. On the whole this has the effect of making the gains at each age more than those shown in Tables XI to XIV. This procedure was not followed in the case of the Woolley data, because it is re-test material.

The tables giving the data, as thus transmuted to this new basis, are not given here but a comparison of them with Table VII shows the following equalities of gains:

1. Simpler functions: Gilbert's girls from eleven to thirteen, Bickersteth's Oxford girls from eleven to thirteen, Pyle's girls from nine to eleven, from nine to twelve, and from twelve to fifteen, made the same respective gains as shown by my data; Pyle's boys from thirteen to fifteen, and Dewey, Child, and Ruml's boys from nine to eleven, and from eleven to thirteen

made the same respective gains as do my own group. By one-year periods there are very few equalities of gains in all these data.

2. *Memory functions:* The boys tested by Gilbert and the girls tested by Pyle (1920) both made gains from nine to eleven the same as were made by my re-test group. Rejecting the results of the Italian vocabulary test does not make any difference in these equalities.

3. *Higher functions:* Gilbert's boys from nine to eleven, Pyle's 1920 boys from eleven to thirteen, Pyle's 1920 girls from nine to eleven made the same gains as are shown in Table VII.

Attention should be called to the results of Netschajeff's eight immediate memory tests. No variabilities are given so the gains have been averaged. While the different tests are not comparable, yet they are similar enough that averaging the gains is not in serious error. The data show the following average gains:

TABLE XVI

NETSCHAJEFF: AVERAGE GAINS IN MEMORY

Ages	*9–10*	*10–11*	*11–12*	*12–13*	*13–14*	*14–15*	*15–16*	*16–17*
Boys	.11	.61	.21	.13	.90	.21	.16	−.17
Girls	.20	.57	.62	.33	.10	.03	.56	.20

If we had the variabilities to use in making the gains in the different tests comparable, there is no doubt that the combined results would still show gains from nine to sixteen. One cannot safely generalize upon the results of each test separately, because one test, requiring not more than three or four minutes, is not an adequate test of a function. Netschajeff's results have been used quite extensively, and some generalizations of doubtful validity have been based upon them; e. g., "The above eight series of twelve each . . . showed that each kind of memory here tested increased with age, with some slight tendency to decline at or just before puberty." Some of the tests actually do not show a decline in memory power at any age, though the rate of gain is decreased; there is no time between nine and seventeen when a positive gain is not shown by some one or more of the individual tests, while the average for each year is positive, except at sixteen–seventeen for boys.

It should be observed that the boys from thirteen to fourteen made the largest gains, while my data show the smallest gains at this time; both are probably in error. There is in all probability greater improvement than shown by my data, and less than shown by Netschajeff's.

Lobsien's eight memory tests (no variabilities are given) show the following average gross gains:

TABLE XVII

LOBSIEN: AVERAGE GAINS IN MEMORY

Ages	*9–10*	*10–11*	*11–12*	*12–14½*
Boys	7.25	10.68	2.76	8.19
Girls	4.82	16.00	3.08	8.82

The average of the gains is here more liable to error than is the average gross gain in Netschajeff's data.

The irregular gains, shown by the data from both of these investigations, are not symptomatic of the curve of growth of memory as we have seen from the data from more extensive investigations.

TABLE XVIII

COMPOSITE AVERAGE OF DATA FROM TABLES VII, AND XI TO XV, FORMED BY GIVING THE FOLLOWING WEIGHTS: Minnesota Re-Test Data 10; Woolley Re-Test Data 10; Gilbert 1; Pyle (1913) 3; Pyle (1920) 3; Bickersteth 3; Oxford Girls 3; Dewey, Child and Ruml 4

Ages	*Simpler*		*Memory*		*Higher*	
	B	*G*	*B*	*G*	*B*	*G*
8 to 9	.323	.503	.209	.091	.308	.252
9 to 10	.475	.534	.491	.523	.649	.569
10 to 11	.519	.430	.428	.315	.537	.471
11 to 12	.506	.318	.265	.250	.416	.418
12 to 13	.395	.375	.230	.316	.428	.359
13 to 14	.839	.517	.128	.363	.451	.487
14 to 15	.532	.537	.233	.267	.475	.390
15 to 16	.093	.059	.192	.313	.163	.210
16 to 17	.189	.173	.159	.104	.108	.169
17 to 18	.472	.399	.051	.312	.063	.122

To get a better idea of the probable course of mental development from nine to fifteen I have combined the data of Gilbert, Pyle, Bickersteth, Dewey, Child and Ruml, and Woolley. The averages of the data of Tables XI to XV have been found for the three groups of functions —simpler, memory and higher. In taking these averages the following weights have been assigned to the data from the different investigators: Gilbert—one; Pyle 1913—three; Pyle 1920—three; Bickersteth—three; Bickersteth's Oxford Girls—three; Dewey, Child and Ruml—four; Woolley Re-Test Data—ten; Minnesota Re-Test Data —ten. These composite averages are given in Table XVIII. The curves for these averages are given in Figs. 12 to 14 (page 66). We will consider the ages covered by my data—nine to fifteen.

For simpler functions the two outstanding features of the curves of the composite averages are (1) the general regular trend of the curves showing a constant rate of improvement during these six years, (2) with an exception at thirteen to fourteen for boys—a

TABLE XIX

NUMBER OF CASES IN TABLE XVIII AT EACH AGE

Age	*Boys*	*Girls*	*Total*
8	459	509	968
9	696	781	1,477
10	900	901	1,801
11	984	919	1,903
12	887	1,084	1,971
13	913	945	1,858
14	1,449	1,429	2,878
15	1,164	1,090	2,254
16	946	916	1,862
17	705	706	1,411
18	475	454	929
Total	9,578	9,734	19,312

	Between Ages 9 and 15
No. of Boys	6,993
No. of Girls	7,149
Total	14,142

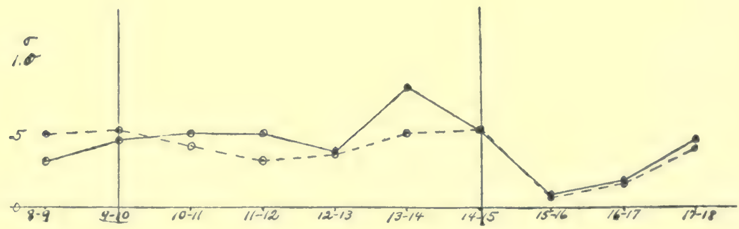

FIG. 12. SIMPLER FUNCTIONS. (COMPOSITE AVERAGE—TABLE XVIII)

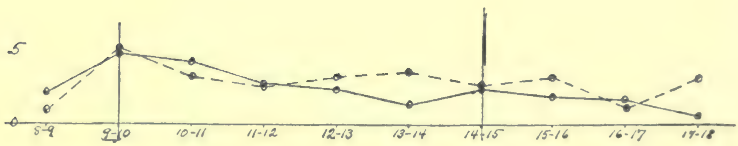

FIG. 13. MEMORY FUNCTIONS. (COMPOSITE AVERAGE—TABLE XVIII)
Boys———— *Girls* — — — —

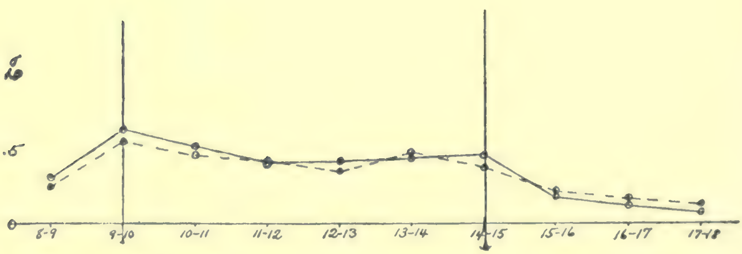

FIG. 14. HIGHER FUNCTIONS. (COMPOSITE AVERAGE—TABLE XVIII)
Boys ———— *Girls* — — — —

Minnesota Re-Test Data Covering Ages 9–15 only

marked rise in the curve. This rise in the curve may be due to an adolescent spurt, but there are some reasons why it is not advisable to accept this as the explanation. Norsworthy (1906) reported data on nine hundred cases in the "A" and "a-t" tests; her data show a slight rise at thirteen to fourteen, but the greatest rise is at ten to eleven, being at this time much greater for boys and some greater for girls than at any other time. Gilbert's data show this rise at thirteen to fourteen, but it is not as great as the rise at nine to ten, or at eleven to twelve. Pyle does not give in 1920 any data on the cancellation test as he does in 1913, so we do not have data to show the effect of using more cases for the same two tests. The Minnesota re-test data show a rise at thirteen to fourteen, which may be accounted for by the probable error of the gains, as has already been pointed out. These facts, together with the smoother curves in the other functions where more adequate tests have been given, indicate that the rate of improvement is probably very nearly constant from nine to fifteen. If the boys' and girls' gains are combined, the new curve is still smoother than either of the curves given in Fig. 12.

In memory functions the curves from nine to fifteen (Fig. 13) are seen to be regular with a drop at thirteen to fourteen for boys, which is probably erroneous; the general trend is toward a decrease in the rate at the later ages. To the extent that superior intellectual ability counts in these memory tests, there is good reason to believe that my data show too great increases at nine and ten, and that as a consequence the slope of the line showing the trend of growth would not be as great as shown in Fig. 13. It would seem that the data give evidence of very nearly straight line improvement from nine to fifteen, and that the slope of the line is somewhere near $-.05$.

The higher functions give the clearest case of steady even growth from nine to fifteen. Keeping in mind how selection helped to raise the gains shown by my data at nine and ten, it is seen that the development of the higher functions from nine to fifteen is at a constant rate; that the rate can be represented by a straight line with a slope of zero. Greater weight is given to the belief that development during these years, not only in higher functions but in the other functions as well, is a straight line affair from the fact that the irregular curves are found where few tests and few

cases are used. An examination of all the curves (most of them not given here) shows how the curves are smoothed by using more tests and more cases, and tend to become more like the re-test curves. More re-test data would probably show still smoother curves. As we approach adequate measurements of the changes at different ages we get curves which approach a straight line.

In forming the composite averages of Table XVIII, the tacit assumption has been made that the average of the gains, as found by these different investigators, would represent more truly the

TABLE XX

Composite Average, Formed by Giving the Following Weights: Minnesota Re-Test Data 10; Woolley Re-Test Data 10; Gilbert 1; Pyle (1913) 3; Pyle (1920) 3; Bickersteth 3; Oxford Girls 3; Dewey, Child and Ruml 4
Growth from 9 to 15 Assumed the Same for All Groups Tested

Ages	*Simpler*		*Memory*		*Higher*	
	B	*G*	*B*	*G*	*B*	*G*
8 to 9	1.113	1.330	.548	.288	.772	.509
9 to 10	.705	.762	.725	.676	1.037	.900
10 to 11	.763	.926	.744	.486	.867	.766
11 to 12	.772	.493	.288	.321	.629	.671
12 to 13	.467	.546	.457	.609	.641	.635
13 to 14	1.121	.675	.203	.627	.546	.691
14 to 15	.545	.574	.200	.244	.654	.490
15 to 16	.154	.177	.444	.377	.285	.307
16 to 17	.400	.240	.326	.080	.275	.331
17 to 18	.884	.521	.106	.564	.171	.185

general trend of growth by giving not only more cases but also a wider selection of cases and tests. It has been pointed out that it is reasonable to assume that the total growth from nine to fifteen is the same for these other groups as for the re-test group. In accordance with this assumption the data of Tables XI to XIV have been transmuted to this new basis and combined to form Table XX, by giving the same weights as were used in forming Table XVIII.

A comparison of Tables XVIII and XX reveals no striking differences, aside from an increased irregularity in the latter case

together with a generally higher level. There are a few changes in relative gains as shown by Table XVIII.

The curves representing the data of Table XX are not given here, but they lead to the same conclusions, as to rate of gain from year to year from nine to fifteen, as were reached from the study of Table XVIII and Figs. 12 to 14; viz., a very nearly constant rate of increase for all functions combined, with evidence both for and against some decrease in rate of growth of memory at the later ages, but with a rather clear case of a constant rate for the higher functions and for the simpler functions.

VII

CURRENT PSYCHOLOGICAL OPINION AND THE RESULTS OF RE-TESTS

What light do the re-test data throw upon current views as to the rate of mental development, and the time at which such development ceases?

In the first place, my data do not show periodicity or rhythm in growth. It may be true that in the growth of the individual there are such times of slower and accelerated change, but to settle adequately this question reliable individual growth curves will be necessary. Such curves must be based upon a very great number of careful measurements, both mental and physical, repeated at shorter intervals than a year, and continued for several years. There are difficulties in the way of getting such accurate individual records; one difficulty is the lack of sufficient mental tests, covering a wide range, to avoid having the results vitiated by practice effect. It is apparent that each individual's curve would have to be derived so accurately that it truly represented just what changes took place from time to time. A group of such curves would tell us about periodicity or spurts in the individual. My data do not give such accurate individual growth curves, and this should be kept in mind in all the discussion that follows. Nor do we have on the mental side anything approaching such curves.

So far as long-time development (a year or more) is concerned, my data indicate a steady rate. It will be observed in this connection that earlier investigations, showing periodicity, often include a very few tests or a comparatively few cases, i. e., were inadequate measures, and that more tests and more cases give evidence of more regular rate of development. Continuity, rather than abrupt transitions, seems to be indicated by the Minnesota re-test data, for the group as a whole.

The conclusions, often drawn from Gilbert's curves, that mental functions are unfavorably affected during the initial and final stages of adolescence, are not borne out by the re-test data. Likewise, the evidence does not support the statement quite current some

time ago, and made by Norsworthy (1906, p. 87) in referring to normal children, "For the gain between nine and ten is usually greater than the improvement between any other two years later on."

On the development of memory we are often told that "Memory for isolated impressions . . . reaches its climax early in the teens," and that "probably the child's memory for words reaches its climax before reaching the teens." The Minnesota re-test data do not show this to be the case up to fifteen, and the Cincinnati re-test data show improvement up to eighteen in memory for seven-, eight-, and nine-place numbers. It may be objected that selection is playing a part which masks the truth. To get at this, I have calculated the gains for the Cincinnati children (the original data will soon be published by Dr. H. T. Woolley) that left school at fourteen to go to work. This group, as shown in Chapter III, included 420 boys and 327 girls at fourteen. At fifteen 388 boys and 285 girls were re-tested; at sixteen, 346 boys and 296 girls; at seventeen, 309 boys and 244 girls; at eighteen, 304 boys and 209 girls. The gains from one year to the next in memory have been turned into standard deviation gains, and are as follows:

Ages	*14–15*	*15–16*	*16–17*	*17–18*
Boys	.261	.444	.079	.183
Girls	.405	.379	.054	.162

This is good evidence that memory power, as tested by immediate memory for digits, does increase at least up to eighteen. Some selection may have been operative to prevent getting the opportunity to re-test all of the original group at each year following fourteen, but it is doubtful if it did to any marked degree; it should be borne in mind in this connection that the working group was made up entirely of children who at fourteen had reached grades five, six, seven, eight, or nine, respectively, and that very few (1.5%) had reached ninth grade, and not very many (15%) were in eighth grade. Whether we use the group that stayed in school (data not given here), the group that left school and went to work, or the combination of both of these groups, the results give evidence for the same conclusion.

"The period of childhood which precedes pubescence, and lasts for about three years, is one in which growth, both physical and

mental, is slower than at any time until near complete maturity." Tables VII, XI to XVIII, and XX show this statement, made in a comparatively recent little book on adolescence, to be at variance from the facts.

The permanence of IQ, indicated by the correlation of abilities at a two-year interval (Chapter VIII), has been found to be very marked. The Stanford-Binet re-tests, some of them at intervals of five to seven years, show a coefficient of .933. This indicates a permanence in relative mental endowment at different ages.

The view is quite commonly held that mental growth goes on at a decreasing rate after eleven or twelve, probably on the average ceasing at times variously placed at thirteen and a half to sixteen. Thus Toops and Pintner (1920) upon the basis of an examination of 1987 children in six of the Pintner Mental Survey tests, give data showing the sigma gains from six to sixteen. From nine to sixteen they are as follows:

9–10	10–11	11–13	12–13	13–14	14–15	15–16
.61	.64	.45	.52	.36	.42	.27

They hold to the common opinion that "average mental growth ceases about the age of fourteen or fifteen; that there may be some increase after these ages, but such increase is probably so slight as not to be measurable by the rough scales of intelligence which we possess at the present time."

On the question of rate of improvement between nine and fifteen the Minnesota re-test data, supplemented by the data from other investigations (Tables XI to XX), indicate very nearly straight line development, particularly for the simpler and higher functions, and probably for the other groups.

As to when growth ceases, the Minnesota re-test data can give only a negative answer—not before fifteen; other data bear this out, at least for a wide range of school children.

The Cincinnati re-test data give results that are in point in answering this question of time of cessation of growth. In Table XV are given the standard deviation gains from age fourteen to age eighteen for the combined group, already reported upon. It must be borne in mind that these gains represent the differences between the median scores of the group at sucessive ages, and that the differences were divided by the average of the variabilities of ages

fifteen, sixteen and seventeen, of each test and sex, and then changed to basis of standard deviation gains. The averages for each group of functions were found. Simpler functions include three tests—tapping 60″, cancellation, and card sorting; memory includes three immediate memory tests—seven-, eight-, and nine-place numbers; higher functions include three substitution tests for all years, and from fourteen to sixteen two sentence completion tests, scored as to number of ideas, and number of sentences correct. I have calculated the gains for the working group separately; they are as follows:

Ages	*Simpler*		*Memory*		*Higher*	
	B	*G*	*B*	*G*	*B*	*G*
14 to 15	.507	.617	.261	.405	.471	.412
15 to 16	.207	.109	.444	.379	.152	.117
16 to 17	.153	.223	.079	.054	.073	.055
17 to 18	.411	.333	.183	.162	.038	.175

There is seen to be some gain for the working group up to eighteen. With memory the break in rate comes abruptly at sixteen to seventeen, for the higher functions at fifteen to sixteen, and for the simpler functions the rate is relatively high at eighteen, there being a marked decrease at ages fifteen to seventeen. The working group probably is not far from the median of total normal unselected population.[1] To the extent that it does represent the median population, the data just given constitute evidence that, on the whole, mental growth does not cease at fourteen to sixteen. We need, however, more re-test studies covering ages fourteen up to eighteen or twenty; such studies should employ a larger and better selected battery of tests, to determine not only what the rate of growth actually is at these higher ages, but also when growth ceases.

[1] This group left school at fourteen to go to work. At that time the distribution by grade reached (in public or parochial school), in per cents, is as follows:

Grade	5	6	7	8	9
Per cent reaching	26	30	28	15	1

VIII

CORRELATIONS BETWEEN MENTAL TRAITS AT DIFFERENT AGES

What is the relative permanence of the mental capacities measured by these tests?

To answer this question our best procedure is to correlate the results of testing a group of children one time with the results derived from testing the same group a year or more later. In this investigation I have used the results of the tests given in 1918 and 1920 to 67 cases—28 boys and 39 girls. The procedure has been as follows: I have found the plus or minus deviation of the score of each individual in each test from the average score in that test for that age and sex. These deviations from the age-average gross scores in each test have been divided by the average of the standard deviations of ages eleven, twelve, and thirteen for each test—the boys' gross score deviations being divided by the appropriate average S.D.'s of the boys, and the girls' gross score deviations being divided by the girls' average S.D.'s. These deviations in each test, being now in terms of the standard deviation of that test, can be combined. Those from the first year's testing have been averaged to give a score for each individual in the four groups of similar functions—simpler, memory, informational, and higher; the deviations (in terms of the S.D.) from the third testing have likewise been averaged; this pair of values for each individual in each of these four groups of functions, represents his standing with reference to the group of the same age and sex at the beginning and at the end of a two-year interval; it furnishes the data for investigating the permanence of the abilities tested.

By taking each individual's deviations from the average for that age and sex in each test, age and sex as factors have been made constant or equalized without using the partial correlation method.

These pairs of values for each group of functions have been treated as raw scores, and the Pearson product-moment formula used to compute the coefficient of correlation. This gives the results shown in Table XXI.

TABLE XXI

CORRELATION BETWEEN MENTAL TRAITS MEASURED AT A TWO-YEAR INTERVAL: UNCORRECTED

	Simpler	*Memory*	*Higher*	*Informational*
Boys	.640 ± .074	.626 ± .077	.838 ± .038	.930 ± .017
Girls	.818 ± .035	.562 ± .073	.868 ± .025	.895 ± .021

Since many of the tests were given but once in any one year there are chance errors present in the results which make the correlations, given in Table XXI, less than the true correlations between the abilities at the two-year interval. These coefficients have, accordingly, been corrected for attenuation. This correction has been made by breaking up each member of each pair of scores into two parts, so that each part includes, as nearly as possible, equivalent tests. The two parts (halves wherever an even number of tests is included in the group of functions) serve as a substitute for first and second trials of the same tests. While this is not as desirable as two trials of the same tests, yet it does give some idea of the probably true correlation. The square root form of Spearman's correction formula (rather than the 4th root form) has been used because it avoids the assumption that the errors in the values of the pairs of deviations in the same series of trials are uncorrelated; the fourth root form of the formula does involve this assumption, and it is conceivable that the chance errors in the first trials of two tests or in the second trials may be correlated. This correction of the coefficients of Table XXI gives Table XXII.

TABLE XXII

CORRELATION BETWEEN MENTAL TRAITS MEASURED AT A TWO-YEAR INTERVAL: CORRECTED FOR ATTENUATION

	Simpler	*Memory*	*Higher*	*Informational*
Boys	.703	.679	.884	.994
Girls	.959	.642	.937	.938

What is the significance of these coefficients? How do they compare with those obtained in other re-test studies?

They indicate that the relative individual differences in these mental traits at any age from nine to fifteen or sixteen persist to a marked degree; that two years after the first testing the same chil-

dren differ very nearly as much in some of the traits as at first, and in all the traits they differ a great deal; that training or experience, while making its contributions to the changes which have been taking place during these two years, has still not decreased very much the relative differences in the abilities of these children. The coefficients of correlation indicate that these abilities are a relatively permanent endowment; that children of different abilities at these ages are not likely to become much more alike as they get older, but may become less alike. In the chapter on Intellectual Ability and Rate of Improvement data will be presented to show the extent to which children do become more or less alike.

It is especially significant that in the group of informational functions we have the highest coefficients, while in the tests grouped as tests of higher functions the coefficients are nearly as high as in the informational group; it must be borne in mind that the latter group, while much influenced by the direct instruction of the school, includes tests and parts of tests which measure higher mental processes, and that in the former group there are several tests which are very much influenced by school instruction. Yet we find the differences persisting to a greater extent in the case of the higher intellectual capacities (as measured by tests in both the group of higher functions and in that of informational functions) than in the case of the other capacities, except the girls' corrected coefficient in simpler functions, which, however, is less reliable. This implies in part that the more permanent differentiation of children consists in differences in mental ability at the higher levels, and that training does not affect in any intrinsic way the relative native endowment at these levels.

The correlations are not as high as they would be if all of the tests had been sufficiently long or difficult to measure adequately some of the superior children; there are several cases among the sixty-seven where first-test scores were so high in some of the tests that little chance was left for the improvement of the next two years to be shown fully by the differences between first and third scores. This works in two ways: (1) There is not the chance to make large gains in score because of having very nearly perfect scores, and (2) an improvement of the same amount in score at the most difficult end of a test or scale is a greater absolute improvement

than at the middle of it, though it is shown by the figures to be the same. Both of these factors lower the gains of some of the superior children and also lower the correlation. Correction for attenuation tends to overcome the effects of chance errors of one kind or another, but, manifestly, does not get at this problem. The coefficients are probably all lowered somewhat by this cause, and are probably lowered in amount for the different groups of functions in the following ascending order: simpler, memory, higher, and informational; at least it seems clear from an inspection of the gross scores that the coefficients of the higher and informational functions are the ones most reduced.

There are not many investigations reporting the correlations between mental traits at different ages of the same individuals. Burt (1911) re-tested a group of about twenty-five boys, twelve and thirteen years of age, eighteen months after the first testing. He does not give the coefficients, but says that they were about the same as those of the tests among themselves at the first testing; these coefficients were from .51 to .76, all being positive. His tests were comparing lines, dealing, card sorting, alphabet sorting, memory, spot pattern, dotting, and mirror drawing. He concluded that the capacities tested are relatively permanent and constitute innate differences in the individuals.

Bobertag (1912) re-testing 83 normal children by the Binet-Simon tests a year after the first testing found the correlation by the Spearman rank formula to be $\rho = .95$, P.E. $= .024$.

Bickersteth (1914–15) re-tested thirty-eight girls a year after the first testing. They were eleven years old when re-tested. Three tests were used—dotting, tapping, and reasoning (analogies). But one coefficient is given, that of dotting; it is .74.

Jones (1917) found the correlations between total average of the tests each year with that of the other years to be as follows:

	2nd Year	*3rd Year*	*4th Year*
First year average	.74	.69	.76
Second year average	..	.71	.76
Third year average	..	..	.73

No corrections for attenuation were made, and so we do not know the probably true relationship.

IX

CORRELATIONS BETWEEN GAINS IN DIFFERENT GROUPS OF FUNCTIONS FOR A TWO-YEAR INTERVAL

To determine the extent to which gain in one function is related to gain in other functions, the correlations have been calculated between gains in all pairs of the four groups of functions—simpler, memory, higher, and informational, using the 67 cases at the two-year interval. The sigma deviations of each individual in each test from the average score of that test for the same age and sex have been computed as in Chapter VIII, and the averages of these deviations for each group of functions have been found for each of the 67 cases for the first and third testings. This gives a pair of values for each individual in each group of functions. The first of the values in each group of functions was subtracted from the second; this difference for each individual is the gain or improvement of that individual during the two years—gain measured by the difference between his early and late plus or minus deviations from the average for the same age and sex. Each individual has four gains—one each in simpler, memory, higher, and informational functions.

In finding these correlations the boys and girls have been taken as one group; this has been done because the rates of gain in the four groups of functions have been found to be approximately equal for both boys and girls (see Figs. 8 to 11). The correlations between the gains in different functions have been computed by the Pearson product-moment formula, and are given in Table XXIII.

TABLE XXIII

Correlations (Uncorrected) between Two-Year Gains in Different Groups of Functions, 67 Cases (28 boys and 39 girls), Age and Sex Having been Equalized

SM[1]	*SH*	*SI*	*MH*	*MI*	*HI*
.049	.038	.248	.314	.102	.236

[1] *S, M, H, I* mean respectively simpler, memory, higher, and informational.

It is seen at once that the P.E.'s of these coefficients are quite large. Since we are interested in the true relationship between gains in different groups of functions in order to know more of the significance of a child's improvement in each group of functions, the raw coefficients are not what we want. A nearer approach to a knowledge of the true interrelationship can probably be made by correcting the raw coefficients for attenuation. This correction has been made by splitting the gains in each group of functions into two parts, including in each part as nearly equivalent tests as possible (as in Chapter VIII); the square foot form of the Spearman formula has been used. The corrected coefficients are given in Table XXIV.

TABLE XXIV

CORRELATIONS BETWEEN GAINS IN DIFFERENT GROUPS OF FUNCTIONS, CORRECTED FOR ATTENUATION BY THE SPEARMAN FORMULA

SM	*SH*	*SI*	*MH*	*MI*	*HI*
.295	.190	.759	.531	.198	.472

What interpretation best explains these correlations between gains in different groups of mental functions for two years?

In the first place, gain or improvement in one group of functions is shown not to have an inverse relationship with gain in any other functions. From these coefficients it cannot be said that gain in one kind of functions during a two-year period is closely related to loss in some other functions. So far as long-time changes are concerned, these correlations do not give support to the doctrine of compensation which has often been advanced to describe mental growth, e. g., " the strong advance of one intellectual activity carries with it a corresponding depression of the other intellectual activities."

In the second place, if we apply the criterion, " a coefficient of correlation is significant if it is three times its P.E.," we find three of the raw correlations are significant, simpler-informational, memory-higher, and higher-informational. This means that gain or improvement in one function tends to be associated positively with gains in other groups of functions, that the chances of these coefficients occurring by mere hazard are as 1 to 25 for the smallest one, and as 1 to 150 or more for the largest ones.

In the third place, the unreliability of the measures and the small number of cases, do not enable us to say just what the true interrelationships are.

Furthermore, we see by comparison of these coefficients with those obtained in Chapter VIII (correlations between status at two-year intervals in the four groups of functions — Tables XXI and XXII) that status is a better means of prognosis than is improvement or gain.

X

CORRELATIONS BETWEEN INTELLECTUAL ABILITY AND RATE OF IMPROVEMENT

What is the extent of the relationship between intellectual ability and rate of improvement for the 67 cases for two years?

An exact method of determining this relationship is to calculate the correlation between IQ and the amount of improvement in the different functions. As measures of improvement the same data have been used as in calculating the correlations between gains in Chapter IX.

The Minnesota re-test data give four measures of IQ in 1920, that is, at the end of the experiment: (1) the scores in the Army Alpha; (2) the scores in the Thorndike Group Intelligence test, III, series L; (3) grade reached in school; (4) school marks in mathematics, history, geography, reading (or literature) and language (grammar or composition).

The mental age of each individual as a plus or minus sigma deviation from chronological age was computed for (1) and (2); the plus or minus sigma deviations from normal age for reaching a given grade were computed for (3); the plus or minus sigma deviations of the average marks of each child in the five subjects from the average marks for the same age and sex were computed, giving the fourth measure. These four sets of sigma deviations for each individual were averaged, giving the quantities used as measures of IQ.

The correlations between IQ, as thus determined, and the

TABLE XXV

Correlations between Intellectual Ability and Amounts of Gain in Different Groups of Functions During a Two-Year Interval: Uncorrected and Corrected for Attenuation

	IQ—S.[1]	*IQ—M.*	*IQ—H.*	*IQ—I.*
Uncorrected (027) . . .	.027	.243	.241	−.047
Corrected	.206	.266	.356	−.054

[1] *S, M, H, I* mean respectively simpler, memory, higher and informational.

gains in simpler, memory, higher and informational functions were calculated and corrected for attenuation as in Chapter VIII. Table XXV gives the raw and corrected coefficients.

Applying the criterion of relative size of *r* and P.E., the second and third of these raw coefficients seem to be of some significance.

The gains in the four groups of functions have been averaged (simple average) and the correlation between this average and IQ has been calculated. This is found to be .249.

The slight negative correlation between IQ and improvement in informational functions is readily seen to be spurious when the raw scores of the different individuals of high IQ's in visual vocabulary, Woody arithmetic and spelling are examined. Manifestly an individual, spelling fifty-seven out of sixty words at age twelve, could not make the same gain during the next two years as an individual spelling but six words at age twelve, or as an individual spelling thirty-eight words at this age; nor could a child eleven years old, scoring one hundred seventy of the one hundred ninety visual vocabulary words, have the same possibilities of gain as other children of the same age who scored one hundred five or one hundred eight words. Such situations as these are numerous enough to show that the correlation of IQ and gains in informational functions is decidedly spurious; they are numerous enough to show that the correlation in the case of the higher functions is much too low; they are present to a slight extent in the tests of memory functions; in the case of the simpler functions the presence of such scores does not seem to be confined to persons of high IQ.

All this means that the children of highest intellectual ability were not adequately tested; that the low correlations found between IQ and the gains in the tests which we believe measure the higher intellectual processes, are not the true correlations, but are too low; that no correction formula will go back of the failure to measure adequately these children of high IQ and give the true correlation. This problem needs to be attacked by using better and more adequate measures of the individuals tested.

From all these considerations it is safe to conclude that the data show low, though probably significant, positive correlations between IQ and improvement, and that this correlation is highest in those tests which measure the higher intellectual capacities.

XI

SUMMARY

Briefly stated, the following conclusions summarize the more significant findings of this investigation:

1. The rate of gain, determined by annual re-tests of 171 children, ages nine to fifteen, in grades four to nine, using a battery of eighteen tests, is practically a straight-line affair, decreasing some at the later ages. Selection of brighter children at the earlier ages has probably magnified the decrease in rate at the later ages.

2. The rates of improvement for boys and girls suggest no significant sex differences.

3. Increasing the number of cases by utilizing other data, most of which are not re-test data, has the effect of smoothing the curves of growth; in the case of the higher and simpler functions the rate not only approaches a straight line, but the slope of the line representing the rate approaches zero. This suggests that more cases and a more adequate battery of tests would probably show the rate of improvement to be best represented by a straight line with a slight negative slope—probably between .0 and −.05.

4. As to age of cessation of mental growth, the Minnesota re-test data show growth until age fifteen, the highest age tested. The Cincinnati re-test data show some growth until the highest age tested—age eighteen—though the amount of improvement in the case of the higher functions and in the case of the memory functions is relatively small after sixteen. More re-tests of larger groups of children, ages fourteen to twenty, by a wider selection of tests, are needed to furnish the evidence for a conclusive answer to this question.

5. The doctrines of compensation, adolescent spurt, pre-adolescent spurt, and other similar interesting characterizations of mental development, are not supported by the experimental annual re-test data here presented.

6. The correlations between abilities at a two-year interval in the four groups of functions (simpler, memory, higher, and informational) are found to be high, the corrected coefficients indicating that these abilities are a relatively permanent endowment.

All facts considered, the relative permanence seems to be greatest in those abilities which are usually thought of as indicating greater intelligence. Further evidence of this relative permanence is given in (7).

7. The correlations between two-year gains in the different pairs of groups of functions (for 67 cases) are low but positive; three of the uncorrected and four of the corrected coefficients are large enough to give direct evidence of a positive association of improvement in one group of functions with gain in another group of functions.

8. Gains or Improvement, and IQ are found to have low positive correlations in three cases—simpler, memory, and higher—and a low negative correlation, practically zero, in the case of the informational group. This latter is due to inadequate testing of the superior children. Inadequate testing of superior children in the higher functions accounts for the low correlation found between IQ and higher functions. No correction for constriction of correlation due to inadequate testing can be made (reference is here made to failure to give hard enough or long enough tests to show the abilities of the superior children at the final testing, so that the difference between first and last testings would represent the real improvement of these children). All we can say is that many of the brighter children had no opportunity to make as large gains as the children less bright, and that, as a consequence, the obtained correlations between IQ and gains in higher functions, for example, are much too low—how much too low, we do not know. Further experiments, carefully planned and carried out, are needed to determine the extent of the correlations between intellectual ability and rate of improvement.

BIBLIOGRAPHY

Baldwin, B. T., and Stecher, L. J. (1921). *Psychological Bulletin*, 18, No. 2.

Ballard, P. B. (1913–14). *Journal of Experimental Pedagogy*, 2, pp. 396–405.

——— (1915–16). *Journal of Experimental Pedagogy*, 3, pp. 153–161.

Berry, C. S. (1913). *Psychological Bulletin*, 10, p. 77.

Bloch, E. and Lippa, Hedwig (1912). *Zeitschrift f. Angewandte Psych.*, 7, pp. 397–409.

Bickersteth, M. E. (1917). *British Journal of Psychology*, 9, pp. 23–73.

Binet and Henri (1894). *L'Annēe Psychologique*, I, pp. 1–23.

Bobertag, O. (1912). *Zeitschrift f. Angewandte Psych.*, 6, pp. 495–538.

Brown, Wm. (1910). *British Journal of Psychology*, 3, pp. 296–322.

Burk, F. (1898). *American Journal of Psychology*, 9, 253–326.

Burt, Cyril (1911). *Journal of Experimental Pedagogy*, 1, pp. 93–112.

——— (1909–10). *British Journal of Psychology*, 3, pp. 94–177.

Chotzen, F. (1912). *Zeitschrift f. Ang. Psych.*, 6, pp. 411–494.

Dewey, E., Child, E., and Ruml, B. (1920). *Methods and Results of Testing School Children.* E. P. Dutton & Co., New York.

Doll, E. A. (1921). *Growth of Intelligence*, Psych. Mono., XXIX, No. 2.

Ebbinghaus, H. (1897). *Zeitschrift f. Psych. u. Phys.*, XIII, 401–463.

Ellison, Louise (1908). *American Journal of Psychology*, 19, pp. 253–260.

Gilbert, J. A. (1894). *Studies from Yale Psych. Laboratory*, II, pp. 40–100.

Goddard, H. H. (1913). *Psychological Bulletin*, 10, p. 75.

Gray, P. L. (1915–16). *Journal of Experimental Pedagogy*, 3, pp. 310–318.

Green, J. A. (1915–16). *Journal of Experimental Pedagogy*, 3, pp. 318–322.

Hollingworth, L. S. (1920). *The Psychology of Subnormal Children.* Macmillan, New York.

Jones, E. S. (1917). *Influence of Age and Experience on Correlations Concerned with Mental Tests.* University of Chicago Press.

Kimmons, C. W. (1916). *Child Study*, IX, pp. 61–64.

Lobsien, Marx (1901). *Zeits. f. Psych. u. Phys.*, XXVII, pp. 34ff.

Meumann, E. (1907). *Vorlesungen zur Einführung in die Experimentelle Pädagogik*, Bd. I, s. 543–555.

——— (1911). *Vorlesungen*, Bd. I, s. 705–725.

Murdoch, K. (1918). *Journal of Applied Psychology*, 2, 243–249.

Netschajeff, A. (1900). *Zeits. f. Psych. u. Phys.*, Bd. 24, Heft 5, pp. 321–351.

Norsworthy, Naomi (1906). *Psychology of Mentally Deficient Children.* Columbia University Contributions to Philosophy, Psychology and Education, New York.

Pyle, W. H. (1913). *The Examination of School Children.* Macmillan Co.

——— (1915). *Journal of Educational Psychology*, 6, pp. 151–156.

——— (1920). *A Manual for the Mental and Physical Examination of School Children* (Revised). University of Missouri Bulletin, Vol. 21, No. 12.

Rusk, R. R. (1909). *Brit. J. Psych.*, 3, pp. 349–385.

Simpson, B. R. (1912). *Correlations of Mental Abilities.* Contributions to Education, No. 53, Teachers College, New York.

Smedley, F. W. (1902). *Report of U. S. Commission of Education*, Vol. I, pp. 1129–1138.

Smith, Frank (1913). *British Journal of Psychology*, 6, pp. 321–362.

Strayer, G. D. and Thorndike, E. L. (1913). *Educational Administration.* Macmillan Co.

Terman, L. M. and Childs, H. G. (1912). *Journal of Educational Psychology*, 3, especially pp. 205–208.

——— (1919). *The Intelligence of School Children.* Houghton, Mifflin Co., New York.

Thompson, G. H. and Smith, F. W. (1915–17). *British Journal of Psychology*, 8, pp. 48–51.

Thorndike, E. L. (1913). *Mental and Social Measurements.* Teachers College, New York.

——— (1914). *Educational Psychology.* Vol. III. Teachers College, New York.

——— (1914–15). *Psychological Clinic*, VIII, p. 189.

——— (1917). *The Elimination of Pupils from School.* U. S. Bureau of Education, Bulletin No. 4, 1917.

Tucker, A. W. (1911). *British Journal of Psychology*, 4, pp. 33–43.

Toops and Pintner, Rudolph (1920). *Journal of Experimental Psychology*, 3, pp. 231–242.

Valentine, C. W. (1913). *British Journal of Psychology*, 6, pp. 190–216.

Von Käthe and Busemann (1914). *Zeits. f. Ang. Psych.*, 9, pp. 273ff.

Whipple, G. M. (1910). *Manual of Mental and Physical Tests.* Warwick and York, Baltimore.

——— (1914, 1915). *Manual of Mental and Physical Tests—Simpler and Complex Processes.* Warwick and York, Baltimore.

Winch, W. H. (1906). *British Journal of Psychology*, 2, pp. 220–225.

——— (1914). *British Journal of Psychology*, 7, pp. 190–225.

Winteler, *Die Experimentelle Pädagogik*, II, Bd.

Woodrow, Herbert (1917). *Journal of Educational Psychology*, 8, pp. 85–96, 151–165.

Woodworth, R. S. (1912). *Psychological Review*, 19, pp. 97–123.

Woolley, H. T. and Fischer (1914). *Psychological Monographs*, No. 77, 247 pp.

——— (1915). *Journal of Educational Psychology*, 6, pp. 521–550.

Wreschner. *Zeits. f. Psych. u. Phys.*, 1 Abteilung, Ergänzungsband 3.

Wyatt, Stanley (1913). *British Journal of Psychology*, 6, pp. 109–133.

Ziehen, Th. (1898). *Sammlung v. Abhandlungen a. d. g. der Pädagogischen Psych. u. Phys.* I Bd, 6 Heft. 66 pp.

VITA

FOWLER DELL BROOKS was born in Adelphi, Ross Co., Ohio, in 1885.

He attended the public schools of Ohio, graduating from the Baltimore, Ohio, high school in 1901. Undergraduate work was done in Baker University, Baldwin, Kansas, and in the Nebraska State Normal School at Peru, Nebraska; from the former institution the A.B. and A.M. degrees (in mathematics and philosophy) were received in 1911. Graduate work in education led to the A.M. degree at the University of Oklahoma in 1915 and to the A.M. degree at Teachers College, Columbia University, in 1916. An additional year of graduate work was done at Columbia University during the academic year 1920–21.

Educational experience embraces two years as teacher in the rural schools of Ohio, two years as principal of village schools in Nebraska, three years as superintendent of schools in Nebraska and Idaho, and the following: 1910–11, mathematics assistant, Baker University, Baldwin, Kansas; 1911–15, superintendent of schools, Guthrie, Oklahoma; 1915–17, assistant professor of psychology and education, University of Oklahoma, Norman, Oklahoma; 1917–20, director of Training School, Minnesota State Teachers College, Mankato, Minnesota.

Previous Publications: "Time Assignment and Rate of Improvement in Handwriting," *Journal of Educational Psychology*, September, 1919.

Psych
B87332ch

Brooks, Fowler Dell 612933
Changes in mental traits with age,
determined by annual re-tests.

UNIVERSITY OF TORONTO
LIBRARY

DO NOT
REMOVE
THE
CARD
FROM
THIS
POCKET